

Ventilation

Mine Gases And Their Detection

Atmospheric Gases

- Mixture of several gases and their composition extends from the surface of the earth from the sea level upto an altitude of at least 25km.
- Constituents by weight % by volume %

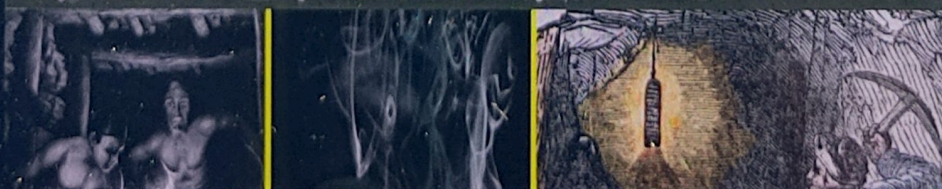
Oxygen	23.15	20.93
Nitrogen	76.81	79.04
Carbon dioxide	0.04	0.03
- Air is a mixture and not a chemical substance therefore its components can be separated by cooling it to about -196°C by fractional distillation.
- Argon is an inert gas 0.94% by volume in the atmospheric air.

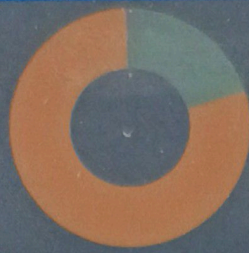
Analysis of air in the return airway of a gassy coal mine



Types Of Damps

- **Black Damp** – It is a mixture of the extinctive gases, carbon di oxide and excess nitrogen. It is also sometimes referred as *choke damp* or *stythe*.
- **Fire Damp** – It is mechanical mixture of gases chiefly inflammable gases given off naturally from coal and consisting for the most part of methane CH₄.
- **White Damp** – It is a mixture of carbon monoxide CO.
- **Stink Damp** – It is a mixture of sulphuretted hydrogen, H₂S (hydrogen sulphide).
- **After Damp** – It is a mixture of gases existing in a mine after an explosion of fire damp or coal dust or explosives.

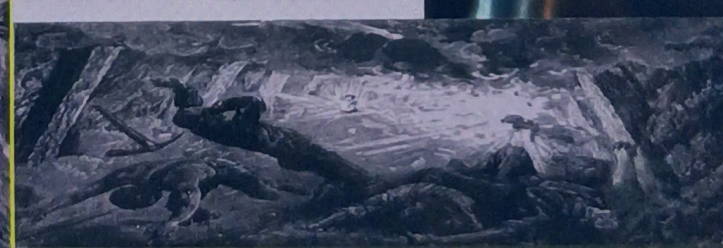
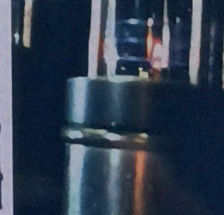
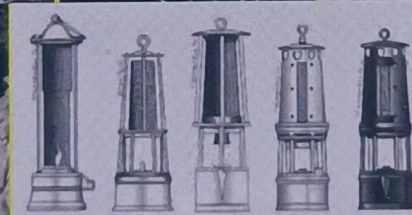




■ Oxygen
■ Nitrogen
■ CO₂
■ Methane

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The Gas Laws

- **Boyle's Law** - The volume of given mass of gas varies inversely as the absolute pressure if the temperature remains constant.

$$V \propto \frac{1}{P}; P_1 \times V_1 = P_2 \times V_2 = \text{Constant}$$

where P_1 and V_1 are initial absolute pressure and volume respectively and P_2 and V_2 are final absolute pressure and volume respectively.

- **Charles's Law** - The volume of a given mass of gas is directly proportional to its absolute temperature when the pressure is constant.

$$V \propto \text{abs. temp } T, \text{ or } \frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{273+C_1}{273+C_2} = \text{Constant}$$

where T_1 and T_2 are absolute temperatures and C_1 and C_2 are the temperatures observed on Centigrade scale.

The absolute temperature is also known as thermodynamic temperature and it is equal to the temperature in °C + 273.15.

- **Combination of Boyle's law and Charles's law** - If a given mass of gas is subjected to a change of pressure and temperature at one and the same time then

10:46

0:00 KB/s 5G+ 79

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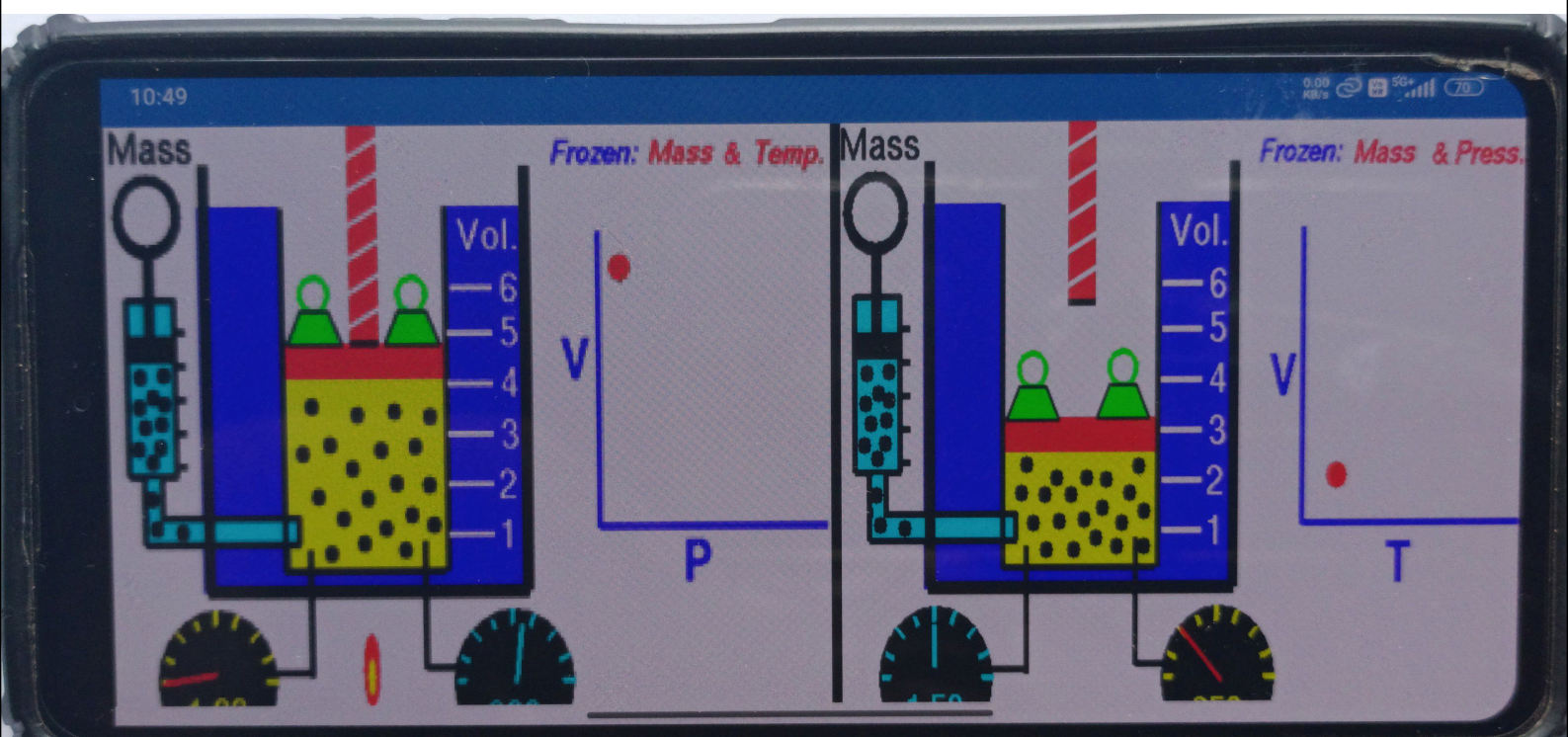
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$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} = \text{a constant, } R$$

R is also known as the characteristic gas constant.



10:51

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- **Graham's law of diffusion** – The relative rates of diffusion of a number of gases vary inversely as the square root of their relative densities.

$$R \propto \frac{1}{\sqrt{D}}$$

Where R is the relative rate of diffusion and D is the relative density

$$\frac{RA}{RB} = \sqrt{\frac{DB}{DA}}$$

Where RA and RB are the relative rates of diffusion of gases A and B respectively and DA and DB are their relative densities.

The density of air, D is given by the equation

$$D = \frac{0.4645 B}{273 + t} \text{ kg/m}^3$$

Where B = Barometric pressure in mm of Hg

t = Temperature in C

Density of air at 15 C and 760 mm Hg is 1.218 kg/m³

Critical Pressure → The pressure above which liquid & gas cannot exist at any temperature.

Critical Temperature → The temperature above which gas cannot be liquified no matter how much pressure is applied.

Mine Gases

Oxygen

- Colourless
- Odourless
- Tasteless
- Slightly soluble in water
- Heavier than air (Sp. gr. 1.1)
- 100 ml. of water at 20°C about 3 ml of Oxygen dissolve
- Critical temp. → -118°C
- Critical pressure → -50 atm
- Support Combustion
- It is most chemically active element which reacts with almost all the element.
- In mines → Breathing
 - Slow oxidation of coal or other carbonaceous material.
 - Burning of flame safety lamps
 - Decay of timber by fungus growth

→ Consumption of Oxygen.

- Person at rest in bed consumes 0.3 lit/min
- Person walking at 3 km/hr consumes 0.78 lit/min
- Person walking at 8 km/hr or doing normal exercise requires nearly 2 lit/min of O_2 .

→ 1% Oxygen H_2 reduce H_2 at oil lamps की light में 30% का reduction होता है।

- Person walking at 8 km/hr or doing normal exercise requires nearly 2 lit/min of O_2 .
- 1% Oxygen अगर reduce होता तो oil lamps की light में 30% का reduction होता है।
और अगर O_2 का % गिरकर 17.5% हो जाय तो oil lamp बुझ जाइगा लेकिन FSL जलता रहेगा।
- human beings can survive at 15% O_2
- Small birds like Canaries can survive upto 8% O_2 .
- Acetylene lamp burns when O_2 % is as low as 12 to 13 %
- Mine air में at least 19% O_2 होना चाहिए
USSR → 20%
USA → 19.5%

Monitoring Device

- UPTRON → To monitor O_2 deficiency.
 - Lucknow manufacturers.
 - Model OXD-2M
- यह hand held device है जो O_2 की deficiency बताता है और अगर O_2 का % preset limit से कम होता है तो यह audible alarm warning देगा।
- It has fast response, long life electro-chemical sensor.
- It has a 3 digit LCD which indicates O_2 concentration → Range → 0 - 30%
- Rechargeable Ni-Cd battery → 110 mAh
→ 27 hrs back
- Alarm is adjustable from 14% to 23% O_2 content.
- Dimensions → 192mm X 80mm X 56mm.
- Weight → 800gms.

→ Dimensions → 192 mm X 80 mm X 56 mm.

→ Weight → 800 gms.

→ Nitrogen

◦ Colourless

◦ Odourless

◦ Tasteless

◦ As heavy as air → Sp. gr. = 0.967

◦ Insoluble in water

◦ It is an Inert gas ना ही जलंगा और ना ही Combustion को support करेगा। लेकिन Plants & animals की growth के लिए जरूरी है।

◦ Critical Temp → -146°C , ◦ Critical Pressure → 35at

→ Carbon-di-Oxide.

◦ Colourless

◦ Odourless

◦ Bitter in taste

◦ Sp. gr. → 1.52

◦ Soluble in water

◦ 100ml Water में 100ml CO_2 dissolve होकर weak acid बनता

◦ It is Incombustible

◦ Doesnot support life

◦ Critical Temp. = -32°C

◦ FSL is extinguished at a CO_2 % of 3-4%.

→ CO_2 is produced due to:-

◦ breathing of men

◦ burning of FSL.

◦ Decay of timber

◦ slow oxidation of Coal

◦ Blasting

◦ Diesel locomotives

→ Effects of breathing CO_2 :-

◦ 3% → breathing doubled (at rest)

◦ 6% → Violent panting, headache, exhaustion

10% → Suffocation & unconsciousness

- Tasteless
- As heavy as air $\rightarrow$ Sp. gr. $\rightarrow$ 0.967
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- Critical Temp $\rightarrow$ -146°C , ◦ Critical Pressure $\rightarrow$ 350

$\Rightarrow$ Carbon - di - Oxide.

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- 6% $\rightarrow$ Violent panting, headache, exhaustion
- 10% $\rightarrow$ Suffocation & Unconsciousness
- 15% $\rightarrow$ Consciousness loss
- 25% $\rightarrow$ Death after hours.

Black Damp

- This is a mixture of CO_2 & Nitrogen in %
- Gas का % normal air के % से ज्यादा होता है
- CO_2 ranges from 0 - 20%.
- N_2 ranges from 80 - 100%.
- Every 5% blackdamp पर 1% O_2 reduce होता है।
- Black damp को clear करने के लिए lime का sprinkling करें and high concⁿ को remove करने के लिए ventilation improve करें।

Carbon Monoxide / Whitedamp / CO

- Carbon / Carbonaceous matter जब कम O_2 में जलता है तो CO produce होता है।
- Colourless
- odourless
- Tasteless
- non-irritating
- Sp. gr. → 0.967
- Combustible → does not support combustion
- hardly soluble in water → at 20°C 100ml water में 2.5ml dissolve होता है।
- burns with light blue flame and will produce CO_2 .
- अगर air में 12% CO present है तो यह explosive mixture form करेगा।

Production of CO in Mine is due to

- ① Oxidation of Coal
- ② Explosives
- ③ Spontaneous combustion
- ④ Methane or coal dust explosion
- ⑤ U/g machinery

Physiological Effects of CO

- 0.02% → headache, discomfort or collapse after 45 min. at work or 2 hrs. at rest.
- 0.12% → heart beat increase after 10 min. of work or 30 min. of rest.
- 0.2% → Unconsciousness after 10 min at work or 30 min at rest.
- 0.5% - 1% → Death after 10-15 min of work.

- after 45 min. at work
- 0.12% → heart beat increase after 10 min. of work or 30 min. of rest.
 - 0.2% → Unconsciousness after 10 min at work or 30 min at rest.
 - 0.5% - 1% → Death after 10-15 min of work.
 - After effects → headache, loss of strength or paralysis

Canary Bird or Munia bird.

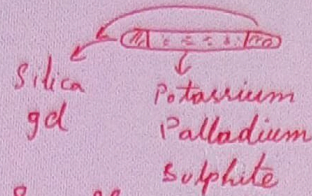
- In this method Canary bird is used to detect CO.
- warm blooded animals → Munia bird or Mouse का use करते हैं क्योंकि CO का इन पर ज़रूरत प्रभाव पड़ता है।
- Rescue operations में इनका use करते हैं।
- सिर्फ fresh birds का use करें।
- इसके help से small % of CO can be detected
- 0.15% CO पर मुनिया → घबरा फड़फड़ाती है और chirping करती है।



- Munia 0.1% CO में अगर expose की जाती है तो बेचैनी show करेगी, लेकिन यह 0.3% पर ही आपको दिखेगा
- 0.3% CO में Munia 2 से 3 meter आगे जाने पर ही अपने perch से गिर जायेगी
- 0.15% CO में 3 meter आगे जाने पर बेहोश हो जाती है and 18 meter में perch से गिर जाती है।
- Ordinary birds 1% से 2% CO में कोई effect नहीं पड़ता और वह कोई sign भी नहीं देगी जब तक मर नहीं जाती है।

PS Detector

- Glass tube में silica gel होता है with light yellow potassium palladium sulphite
- silica gel Glass tube के दोनों ends में होता है
- 120 cm^3 air इसमें 2 minute तक constant rate से डाली जाती है।
- CO light yellow colour का brown colour में change कर देता है।
- Range of instrument $\rightarrow 0.005\%$ to 0.12% of CO

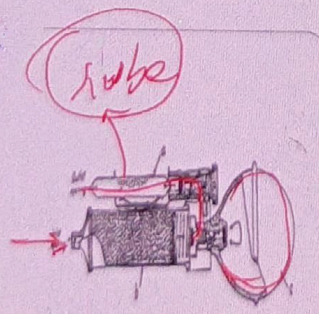


Hopcalite detector

- Principle $\rightarrow$ Oxidation होने पर CO gets converted into CO_2
- hopcalite $\rightarrow$ mixture of manganese dioxide & copper oxide
- Pump की help air pass कराती है।
- hopcalite के कारण CO oxidise हो जाता है और CO_2 में convert होने के साथ temperature increase होता है।
- Detector में एक Thermometer connect होता है जो कि rise in temperature को record करता है।
- Range $\rightarrow 0.005\%$ to 0.015% of CO

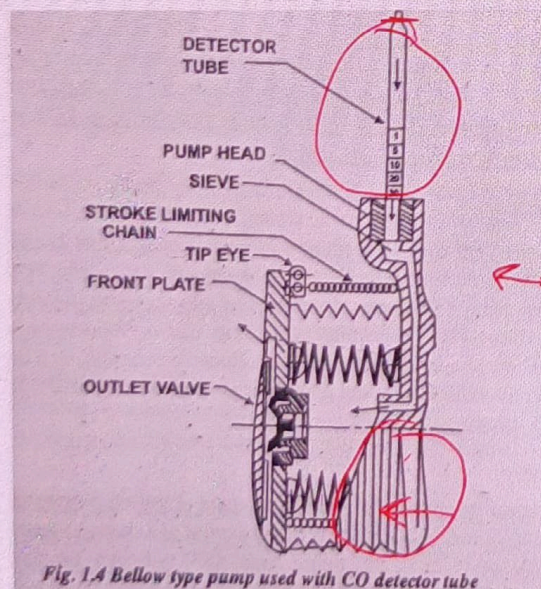
Hoolamite Tube

- Mixture of Iodine Pentoxide & sulphuric acid
- hoolamite greyish white colour का होता है
- CO pass कराने पर यह green, brown or black colour में change हो जाता है। and iodine product होता है।



Drager → Multigas Detector

- इसकी help से CO के अलावा on the spot other gases का % determine कर सकते हैं
- CO की detect करने के लिए Tube के दोनों ends को break करके pump से लगा देते हैं।
- 1 to 10 times pumping करते हैं
- Range → 5 ppm minimum CO detected.
- इस पूरे operation में 1 से 2 minute लगते हैं
- 10 tubes का packet आता है,
- Shelf life of tubes → 2 years.
- Gases that can be detected → CO, CO₂, H₂S, Thylen, methane etc
- Presence of other gases and moisture will not affect the readings.



MSA Detector

- It consist of aspirator, colour scale and CO detecting tubes.

OUTLET VALVE

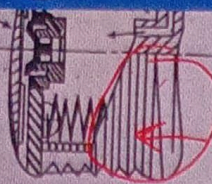


Fig. 1.4 Bellows type pump used with CO detector tube

MSA Detector

- It consist of aspirator, colour scale and CO detecting tubes.
- Range → 10ppm to 1000ppm of CO.
- chemicals → yellow silica gel, palladium sulphate & ammonium molybdate
- Chemical colour changes to green.
- shelf life of tubes → 18 months.



EMCOR CO detection & monitoring system

Specifications

Range → 0 - 50ppm & 0 - 500ppm.

Outputs → 0.4 - 2.0V analogue & control mine flash.

Dimensions → Height → 260mm

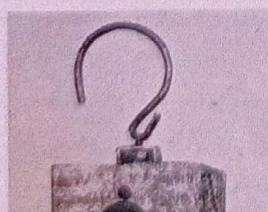
Width → 100mm

Depth → 75mm

Weight → 2.27 Kg

→ Multipurpose analyser for U/g mines

British
National
Coal
Board



Width $\rightarrow 100 \text{ mm}$ Depth $\rightarrow 75 \text{ mm}$ Weight $\rightarrow 2.27 \text{ kg}$ National
Coal
Board $\rightarrow$ Multipurpose analyser for U/g mines $\rightarrow$ It is useful in 3 ways.

- hand held instrument
- has a local alarm
- Continuous monitoring

 $\rightarrow$ It has a LED of $0.4 - 2 \text{ V}$ input

$\rightarrow$ In normal Cond.ⁿ LED 15 seconds में ठीक बार blink करेगा and alarm level increase होते पर 1 second में ठीक बार blink करेगा।

Flame Safety Lamp

 $\rightarrow$ CO bluish flame के साथ जलता है

$\rightarrow$ लेकिन जब CO का % बहुत ज्यादा हो तब

$\rightarrow$ but high % वाली जगह persons की entry के लिए dangerous होता है।

$\rightarrow$ इसलिए FSL का use CO को detect करने के लिए नहीं करते हैं।

Upton India Ltd.

 $\rightarrow$ 2 models $\rightarrow$ ① BCO-1

② BCO-1R

→ इसलिये FSL का use CO की detect करने के लिये नहीं करते हैं।

Uptron India Ltd.

→ 2 models → ① BCO-1

② BCO-1R

→ Models में electrochemical sensors लगे होते हैं।

→ Work on electric supply and इसमें nickel cadmium की rechargeable battery लगी होती है।

→ Mineflash इससे attached होता है to give alarm

→ BCO-1 → Inbuilt sensor होता है।

→ BCO-1R → Remote sited sensor होता है।

→ higher range of detection.

→ Intrinsically safe apparatus.

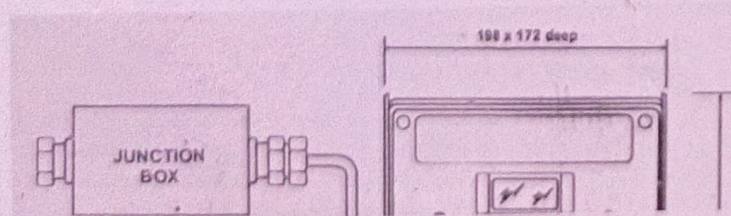
→ Power failure के case में battery से operate होता है।

→ Battery Backup → BCO-1 → 12 days
BCO-1R → 5 days.

→ इसमें एक Liquid Crystal display लगा होता है।

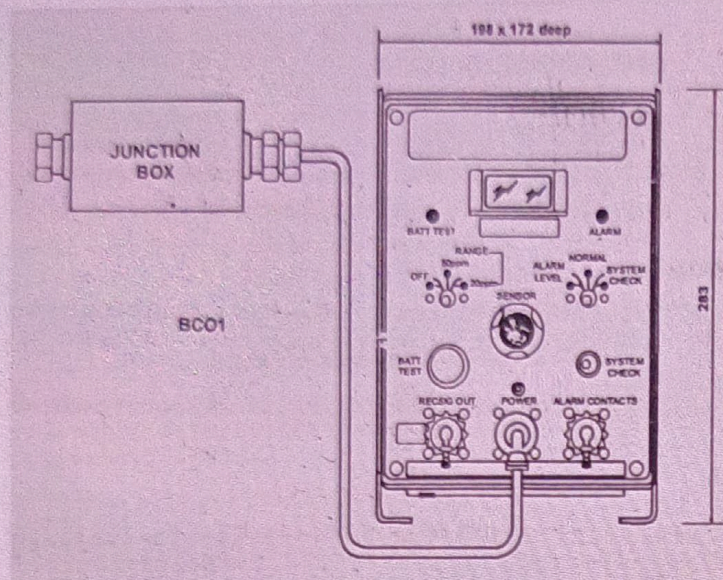
→ Instrument dust & water resistant होता है।

→ Less sensitive to other gases.



→ Instrument also

→ Less sensitive to other gases.



Specifications of BCO-1

- Range → 0 - 200ppm CO
- Temperature → 0 to 40°C
- Humidity range → 20 to 90%
- Input Voltage → 12V DC,
- Alarm range → 10 to 200ppm of CO
- Alarm indication → Red LED
 blinking → Normally 1 time in 15 seconds
 →

→ Alarm range में पहुँचने पर पहले 1 minute तक 2 second में एक बार blink करेगा इसके बाद per second पहली minute में double blinking करेगा।

→ Alarm Voltage → 0.5A, 28V, DC, 10W

Methane Gas

- Also known as fire damp. → mixture of CH_4 in air
- 3 reasons to pay attention to CH_4
 - ① Naturally occurring gas
 - ② It results explosion
 - ③ Methane drainage technology.

Formation of Methane

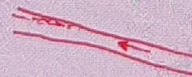
- Coalification of plant materials.
- Cellulose to decay होना के कारण CH_4 Produce
- In coal seam % of CH_4 gas increases with depth.
- CH_4 found in 2 ways in Coal bed.
 - ① free gas compressed in pores or spaces in coal
 - ② Gas adsorbed. In the internal surface of coal

Properties of Methane

- Colourless, odourless & tasteless gas.
- Due to the presence of hydrocarbons it has oily sm.
- CH_4 is lighter than air (sp. gr. 0.554)
- In U/g found in roof of mine working or rise workings of U/g openings.



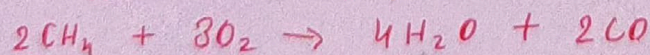
- CH_4 is not toxic.
- Burns with pale blue flame.



- In abundant supply of air, gas burns to produce water vapour and CO_2



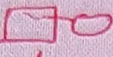
- In insufficient supply of air



- Explosive Mixture → 5.4% — 14.8%

- Explosive Mixture
- LFL → Lower flammable limit
→ जलने वाले mixture की lowest % of CH₄
- UFL → Upper flammable limit
→ जलने वाले mixture की highest % of CH₄

Ways by which CH₄ is found in U/g coal mine

- ① Bleeding from coal or adjacent strata. 
- ② In the form of blowers. 
- ③ In the form of gas outburst.  Pocket
- ④ Release by roof fall. 

Factors affecting CH₄ gas emission.

- ① Nature of coal seam.
- ② Method of mining
- ③ Speed of advance of a longwall face.
- ④ Ventilation.

Methane Layering

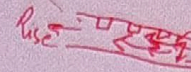
- Low density के कारण methane rise roadway में flow करने लगता है।
- जब methane emit होता है तो dip में उपर की तरफ travel करता है, and उसके roof में settle हो जाता है।
- It depends on → Velocity of air current
→ Roughness of roof.

like 

- Methane का flow roof की तरफ इन चीजों के कारण reduce होता है।

- ① Turbulent air flow
- ② Rough roof

- It depends on → Velocity of air flow
→ Roughness of roof.

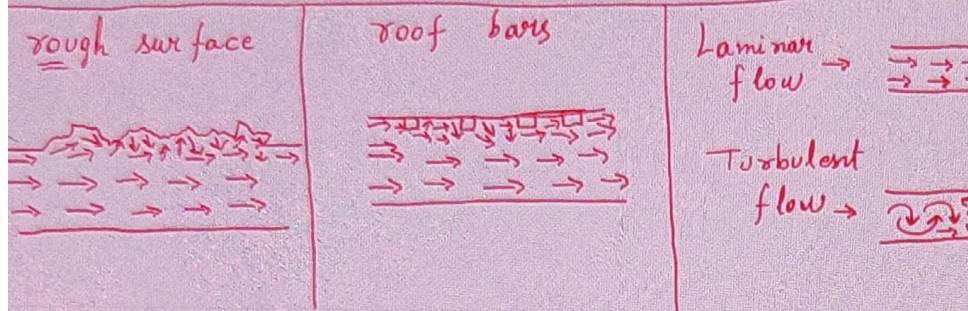
use → 

→ Methane का flow roof की तरफ इन चीजों के कारण reduce होता है।

① Turbulent air flow

② Rough roof

③ roof bars के obstruction के कारण



→ अगर air current down the dip flow करता है तो CH_4 का flow roof में रुक जाता है और वह down the dip flow करने लगता है।

→ Methane layering को रोकने की Critical Velocity.

① for a slope of 1 in 100 → 0.04 m/s

② for a slope of 1 in 2 → 1.45 m/s.

→ Stable CH_4 layering in horizontal airways

↓
depends on → ① Rate of gas emission

② size of airway.

③ Velocity of air.



→ Methane layering तब होती है जब ventilation insufficient होता है। इसके कारण gas disperse नहीं हो पाता है।

→ Large airways में जहाँ पर avg. velocity low होता है, वहाँ पर roof में laminar boundary के form में sufficient thickness की layer बनती है।

thickness

हो पाता है।

→ Large airways में जहाँ पर avg. velocity low होता है, वहाँ पर roof में laminar boundary के form में sufficient thickness की layer बनती है,

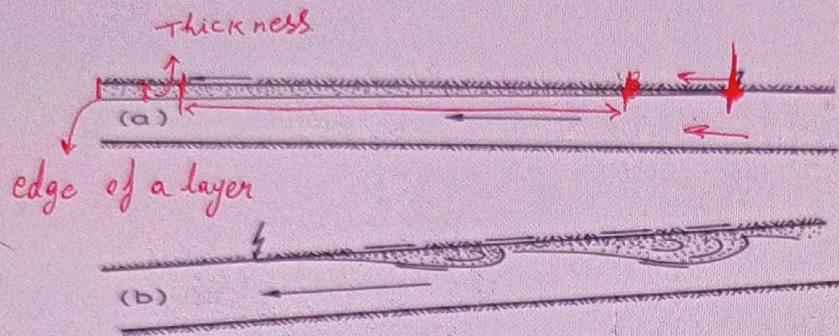


Fig. Methane layering in (a) a level airway
(b) A descensionally ventilated airway

→ इस तरह की layering को turbulent airflow में भी diffuse नहीं कर सकते हैं और यहाँ पर 1m की thickness वाली layer form हो जाती है। और यह air की velocity के direction में बहुत ही slowly move करती है।

→ Other factors affecting methane layering.

- ① Roughness of airway surface
- ② Presence of bends, obstruction etc.
- ③ Nature & location of source of methane emission.

→ Layer में methane का Conc. top से bottom की तरफ reduce होता है। Basically roof में जो methane पायी जाती है pure होती है।

→ at roof level → 38%.

0.3m below roof → only 1%.

→ The edge of a layer → A point जहाँ roof level के ठीक नीचे CH_4 का Conc. कुछ fraction हो जाता है।

The Thickness → $\perp$ dist. b/w roof & edge of the layer.

Layering Number

level के मुकाबले
 CH_4 का conc. कुछ
 fraction हो जाता है,

The Thickness $\rightarrow$ $\perp$ dist. b/w roof & edge of the layer.

Layering Number

$\rightarrow$ Layering no. depends on.

- ① Velocity of ventilating air stream. (m/s)
- ② Rate of gas emission.
- ③ Width of airway.
- ④ Inclination of airway.
- ⑤ Relative density of air and gas.
- ⑥ Roughness of roof
- ⑦ Type of ventilation (asc. or desc.)

$\rightarrow$ Methane layer को describe करने के लिए इन सभी factors को combine करके एक no. से represent करते हैं called Layering No. (L)

$\rightarrow$ Layering No. $\rightarrow$ CH_4 layer की stability and length को indicate करते हैं।

$\rightarrow$ by Bakke & Leach

$$L = \left\{ \frac{v}{g \frac{\Delta \rho}{\rho} \times \frac{Q}{W}} \right\}^{1/3} = \left(\frac{v}{4.32 Q/W} \right)^{1/3}$$

$\Delta \rho$ = density difference of air & CH_4

ρ = density of air.

v = avg. velocity of air (m/s)

Q = quantity of methane emitted (m^3/s)

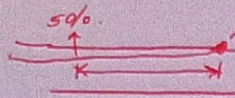
W = width of airway.

$$\boxed{g \frac{\Delta \rho}{\rho}} = 4.32$$

$\rightarrow$ CH_4 layering strongly depends on air velocity

$\rightarrow$ Layering no. अगर 2 से अधिक हो horizontal airway से $\rightarrow$ तेर turbulent diffusion से methane layering को break कर सकता है।

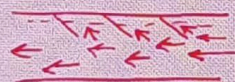
→ Length of layer → Dist. from the source to the source point where the avg. conc. of CH_4 is 5% in the layer.



- Air velocity increase करने पर Layering no. 1.5 से ऊपर होता है और layer कम होने लगता है।
- Level airways में Layering no. 5 से कम नहीं होना चाहिए।
- Layering no. 5 से ऊपर होने पर methane layer में sharp decrease होता है।
- Inclined airways में layering no. airflow के direction पर depend करता है।
- for Ascensional Vent.ⁿ → $L = 8$
- for Descensional Vent.ⁿ → $L = \text{less than } 8$
- for horizontal airways

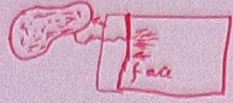
Dealing with CH_4 Layering

- Increase air velocity.
- Vertical or inclined hurdle sheets roof से थोड़ा नीचे लगा सकते हैं।
↓
more air current को roof की तरफ खींच देता है।



- Using venturi blowers → where compressed supply is available
 - 100mm dia fed by 3mm jets of compressed air 70 m की length की layer को break करने के लिए sufficient है।
- By conducting methane drainage → strata में gas emission को reduce कर देता है।
- Controlling rate of gas emission
 - (1) By suitable mining method
 - (2) Length of face
 - (3) Rate of face advance
 - (4) Type of mechanization
 - (5) Method of ground control.
- Working in adjacent less gassy seam.
- Infusion of the seam with water or foam ahead of the face.

Gas blowers

- Coal faces से or cracks से methane gas की एक powerful jet के form में emission होता है इसे Gas blower कहते हैं
- Gas blowers में pure methane होता है 
- Dealing with gas blower.
 - ① Closing or blocking the crack.
 - ② Allow to exhaust naturally
 - ③ Course the gas of blower towards the surface by pipes.

Detection & testing of firedamp

- ① Chemical analysis by taking air samples.
 - ② Flame Safety Lamp.
 - ③ Methane detectors.
- Methane detectors work on following Principles.
- ① Wheat stone bridge → Measuring Unbalanced current.
 - ↳ D 6 (MSA) methanometer.
 - ↳ BMI methane monitor.
 - ② Formation of gas cap. → FSL
 - ↳ Spiralarm gas detector.
 - ③ Diffusion - Combustion - Contraction.

when methane burns in air it produces CO_2 & H_2O

$$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \text{ (water vapour)}$$

2/3 rd space.

Ringrose Firedamp Detector.
 - ④ Difference in Refractive Index of pure air & methane air mixture.
 - ↳ Riken Interferometer
 - ⑤ Infra-red Recorder → Infra-red spectrometry
 - ↳ because methane 7.5 μ की wavelength की waves को absorb कर लेता है।
 - ⑥ Reaction of Methane with chemicals.

② Flame Safety Lamp.

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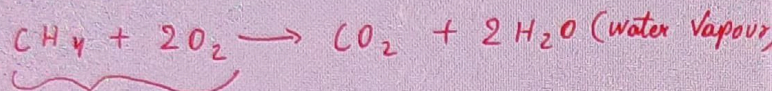
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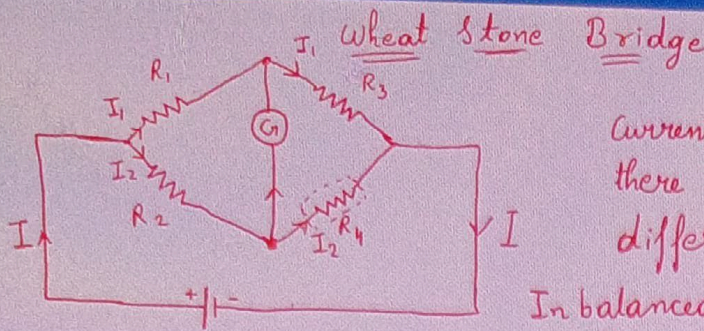
⑤ Infra-red Recorder → Infra-red spectrometry

↳ because methane 7.5 μ की wavelength की waves को absorb कर लेता है।

⑥ Reaction of Methane with chemicals.

↳ Detector tubes

↳ Draeger firm



Current flows when there is potential difference.

In balanced condⁿ

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

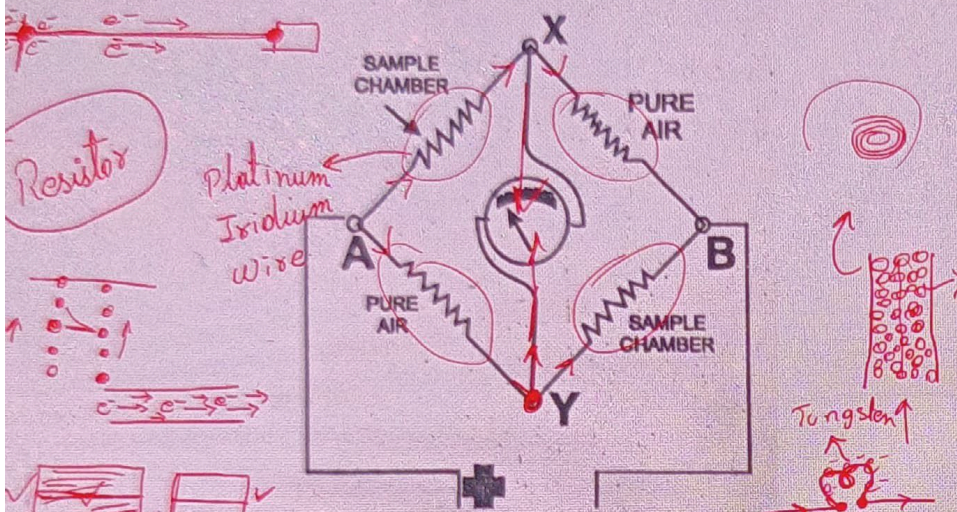


Fig. 1.8 Principle of wheatstone bridge

- Wheat stone bridge के network में 4 wires होते हैं Platinum-Iridium के filament wires.
- जब points A & B को किसी electricity के source से connect करेंगे तो current flow होगा।
- AX & AY के across same voltage होगा।
- X & Y के across current flow नहीं करेगा because potential difference is zero.
- किसी एक wire का resistance change करने पर X & Y के across voltage difference create होगा जिसके कारण X & Y wire में current flow होगा।
- Resistors को Aluminium के chamber में pack करके रखा जाता है।
- इस mines air को उसमें fill करेंगे filament current pass करने पर mines air में methane से react करेगा और wires white hot हो जायेंगे।
- heat generate होने के कारण wire का resistance change हो जाइगा।
- इस के across milliammeter लगा रहेगा जिससे

- connect करने तो current flow होगा।
- A & Y के across same voltage होगा
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- X & Y के across milliammeter लगा रहेगा जिससे current pass होने पर वह methane का % बतायेंगे।

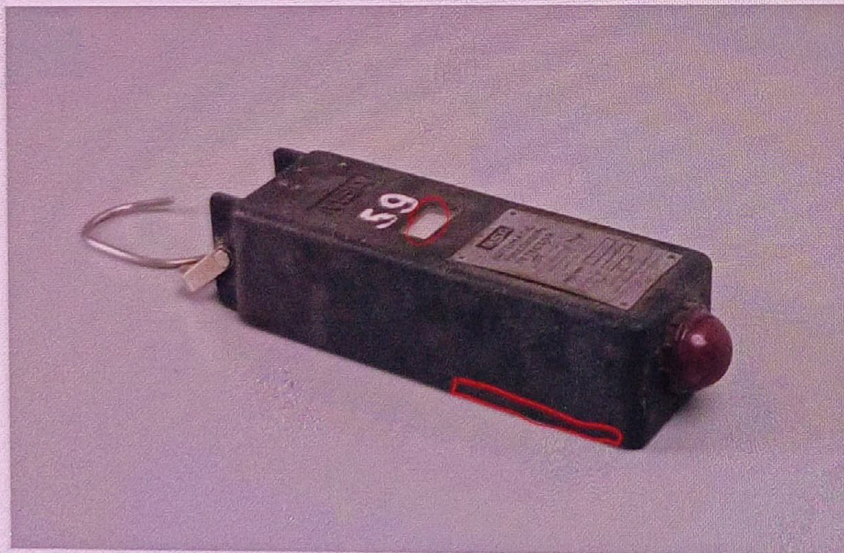
MSA - D6 Methanometer

- Hand held device
- Spot checking of gas accumulation
- Range → 0 - 5%
- Telescopic Tube - for sampling near roof
 - length → 760 m to 1.42 m
- Nickel - Cadmium battery → Rechargeable
 - 2 in no.
 - operate at 2.6V
 - Voltage must be b/w 2.2 to 2.8
- It works on the principle of wheat stone bridge



Automatic Firedamp Detector

- Manufactured by MSA.
- It is a portable instrument for continuous monitoring of methane.
- It has Rechargeable batteries → 10 hrs.
- इसे operate करने के लिए switch नहीं रहता है। Battery लगाने पर यह तुरंत ही काम करने लगेगा।
- Range → 0 - 3% of CH_4 .
- Lamp → 1 flash in 15 sec. in normal condition
- जब methane preset level से exceed कर जाता है तो 1 flash per sec.
- Alarm can be adjusted.
- Installation → ① Person will carry.
② Suspend at the work place.
- AFD operates on the principle of wheatstone bridge



AFD-2 → by Upton India Ltd.

- It has 2 Unit → Flash light alarm & Digital Display
- Methane monitoring device.
- Range → 0 - 5%
- Intrinsically safe instrument
- 0 H. 0 L. → 15 hrs

- Methane monitoring device.
- Range → 0 - 5%
- Intrinsically safe instrument
- Battery Backup → 15 hrs.
- Sensor → works on the principle of diffusion by using electro catalytic pellistor.
- It consist of flash back arrestor / carbon cloth filter.
- 1 flash / 15 secs. in normal cond.ⁿ
- 1 flash / sec. in preset level cond.ⁿ

MEMACS - I

- MSA
- Range → 0 - 5% in general body of air
- It has catalytic pellistors and directly connect with a flame proof relay to control the electrical power supply.
- LCD screen.
- Signal output voltage → 0.4V → 2.0V DC.
-
- It has FAIL safe features.
 - ① Overrange Latch. → Shows 'FS' on LCD.
 - with yellow LED.
 - It can be RESET by placing a magnet on the panel
 - ② Low Battery → 215V at 4m at 42
 - 'Lo Bat'
 - Analog, Multiflash, pilot relays
 - Hi alarm LED will be ON.
 - ③ Filament failure → shows indications on

11:38 0.03 KB/s 5G+ 62
→ 1 flash/sec. in preset level cond.ⁿ

MEMACS - I

- MSA
- Range → 0 - 5% in general body of air
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 - with yellow LED.
 - It can be RESET by placing a magnet on the panel
 - ② Low Battery → 215V से कम होने पर
 - 'Lo Bat'
 - Analog, Multiflash, pilot relays
 - Hi alarm LED will be ON.
 - ③ Filament failure → Shows indications on short circuit or open circuit.
 - Displays 'FS'

Interference Methanometer

- Riken Interferometer → manufactured in Japan.
- Principle → Refractive Index.
- अगर air में methane present है तो air का refractive index increase हो जाता है।
- 2 cells होते हैं → एक में pure होता है और दूसरे में methane and air का mixture होता है।
- जिस light को दोनों cells से पास कराते हैं तो light में lateral shift देखने को मिलता है।

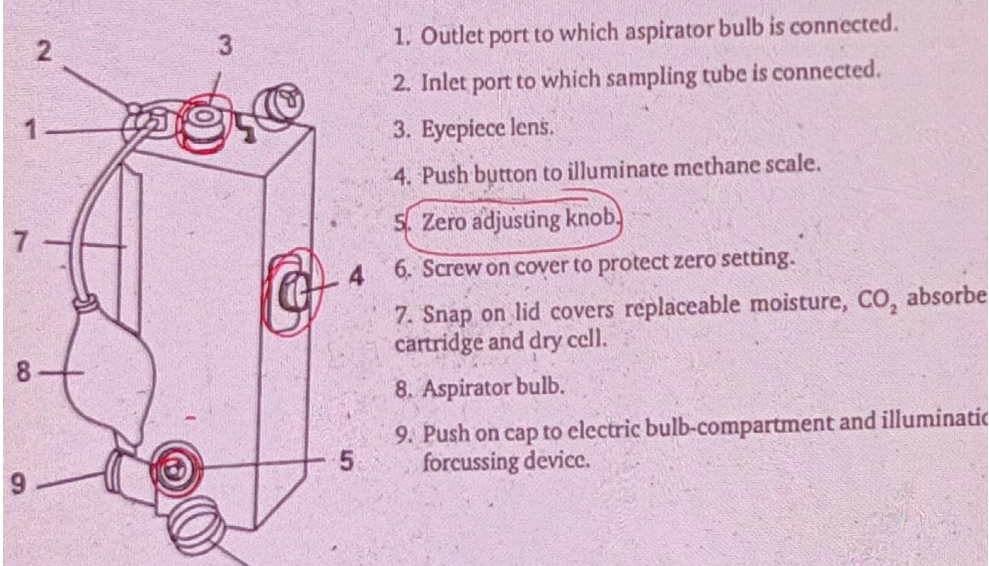
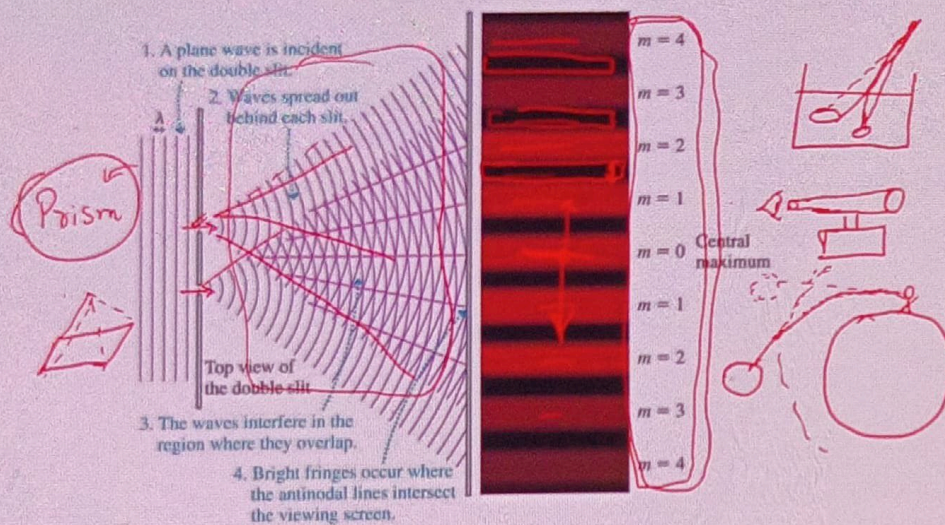
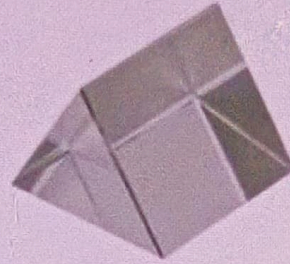
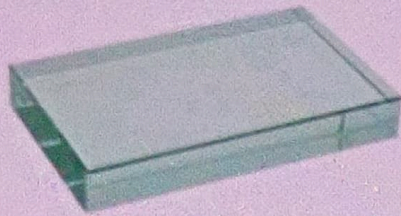
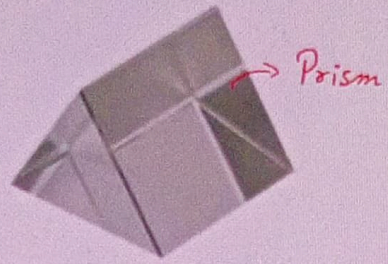
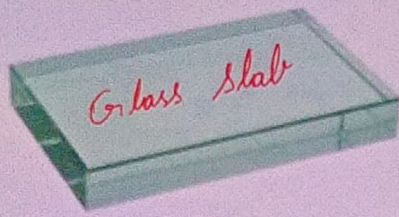


Fig. 1.13 Riken interferometer

- Light में जो lateral shift होता है वह methane की quantity के proportional होता है।
- इसमें Dry cell use होता है।
- एक lens होता है जो parallel beam of light देता है। (emit करता है)।
- lens glass slab की help से 2 separate

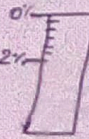
- beam of light emit करता है।
 → एक beam measuring cell से pass होता है & another one comparison cell से।

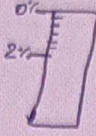


- Path of two light are geometrically equal and अगर दोनों cells का refractive index same है तो optically दोनों light का path equal होगा।
 → Prism को इल्का सा tilt करके interference bands देख सकते हैं।
 → Interference bands measuring scale पर project किया जाता है।

Portable Interferometer Type Methane gas Indicator.

- It is a Portable optical methanometer.
 → CMRS & CSIO
 → It is highly sensitive
 → Range of scale → 0-10% of methane.
 → 0-2% of methane का interval 0.25% है measuring scale पर।
 → 2% - 10% measuring scale पर 0.5% के intervals & markings हैं।
 → Vernier drum → 0-1% at 0.02%
 → Principle → difference in refractive indices of methane air and dry air.
 → Basically works on the principle of interference



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- CMRS & CSIO
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- Vernier drum → 0 - 1% at 0.02%.
- Principle → difference in refractive indices of methane air and dry air.
- Basically works on the principle of interference of light.
- It has one dry cell of 1.5V

→ Parts of optical system.

- ① lamp housing
- ② splitting glass plate
- ③ Lenses & slit
- ④ Prism
- ⑤ Zero adjusting prism
- ⑥ Objective lens.
- ⑦ Microscale
- ⑧ Eye Piece.

- ⑨ Gas chamber
- ⑩ Anti diffusion coiled tube.
- ⑪ Aspirator bulb

Weight → 1 Kg

→ Working

- जब methane को aspirator की help से gas chamber में डाला जाता है तब fringe patterns shift होने लगते हैं।
- black lines में shifting path difference के कारण होता है जो कि methane % के directly proportional होता है।
- Readings battery के voltage पर depend करते हैं।
- Readings rechecking & records के लिए कुछ समय तो available रहता है।

Ringrose Firedamp detector

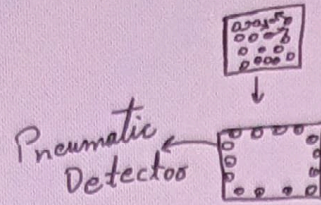
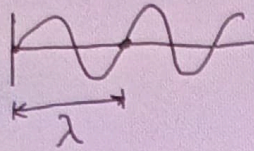
- Principle → Diffusion - Combustion - Contraction
- हर shift में इसके filament को change करना पड़ता है।
- And इसके filament foreign में मिलता है
- इसलिए India में इस use नहीं करते हैं।



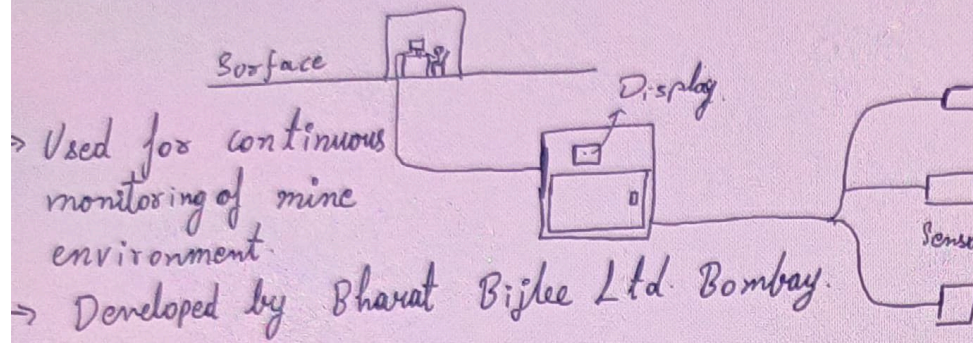
Methanometer based of Spectrometry.

- Ultra Violet → $0.25 - 0.4 \mu$
- Visible band → $0.40 - 0.70 \mu$
- near Infra-Red → $0.70 - 2.5 \mu$
- Middle infra-Red → $2.5 - 25 \mu$
- far infra Red → $25 - 500 \mu$
- Middle infra Red region का use methane के detection के लिए होता है।
- Principle → Each gas absorbs infra radiations of a particular wavelength.
- Methane molecules के IR absorb करने पर molecules का temperature increase होता है जिसके कारण pressure increase होता है
- Pneumatic detector pressure के variation को sense करके methane का % show करता है।

करता है,



Methane Telemonitoring And sensors.



→ Used for continuous monitoring of mine environment.

→ Developed by Bharat Bijlee Ltd. Bombay.

→ जब methane का % preset level से ऊपर जाता है तो यह alarm signal देता है

→ Electronic device

→ It has 2 sets of equipments

(a) U/g i.e. remote station equipment

(b) surface station equipment.

→ It shows →

① Methane %	④ humidity
② Ventilation pressure	⑤ Quantity of air flow
③ Temperature	⑥ CO %
	⑦ CO ₂ %
	⑧ O ₂ %

Methane Drainage

→ Methane gas की गिरने से surface पर ली जाई.

→ Advantages of Methane drainage.

① Less firedamp.

② Main ventilating fan need not to be large

③ Rate of advance of coal face is increased

④ Gas at surface can be utilised for power generation.

→ If the gas emission is more than 20-25 m³/t, then methane drainage must be done.

→ Methane का degassification कहाँ से कहाँ

(a) Seam being worked

(4) Gas at surface can be utilised for power generation.

→ If the gas emission is more than $20-25 \text{ m}^3/\text{t}$, then methane drainage must be done.

→ Methane का degassification कहाँ से करेगा?

(a) Seam being worked

(b) The seam above or below working seam

→ Methods of Methane drainage

① In seam drainage

② Grob drainage by surface boreholes

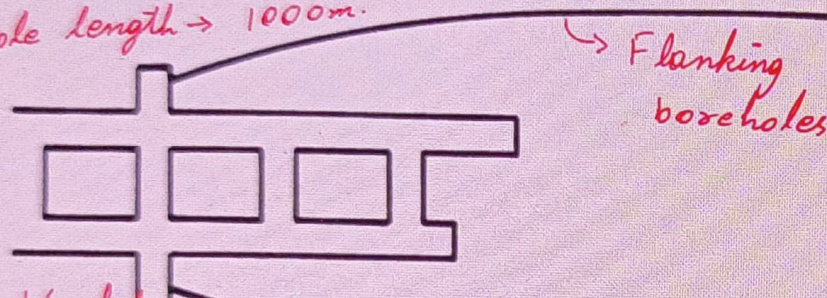
③ Cross-measure borehole method.

④ superjacent heading method or Hirschbach method

⑤ Pack Cavity Method.

→ best for permeable coal.

→ borehole length → 1000m.



→ Spacing b/w holes

↳ ① It depends on permeability

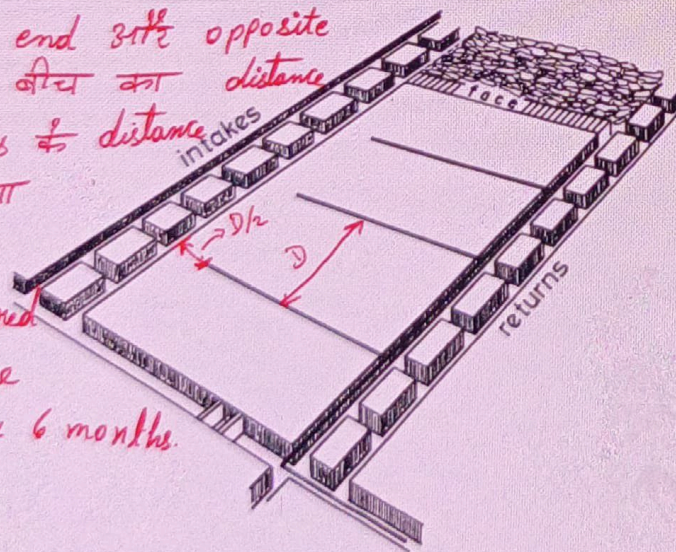
② It can be from 10m to 80m.

Fig. In-seam drainage boreholes to reduce methane flow into advancing headings

→ boreholes के end 30% opposite airway के बीच का distance है boreholes के distance का half होगा

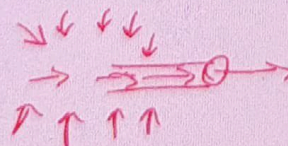
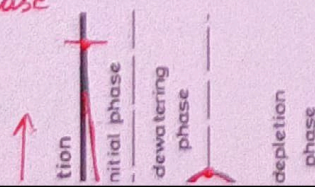
→ Time required for drainage

↳ approx 6 months.



→ Initial phase

↓ gas expand.



for drainage
→ approx 6 months.

Initial phase
gas expand.

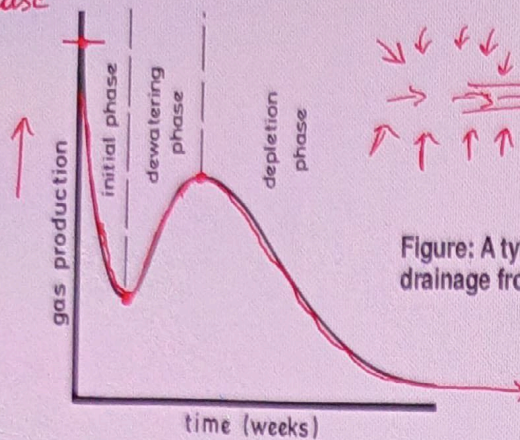


Figure: A typical life cycle of gas drainage from an in-seam borehole

Gob Drainage by surface boreholes.

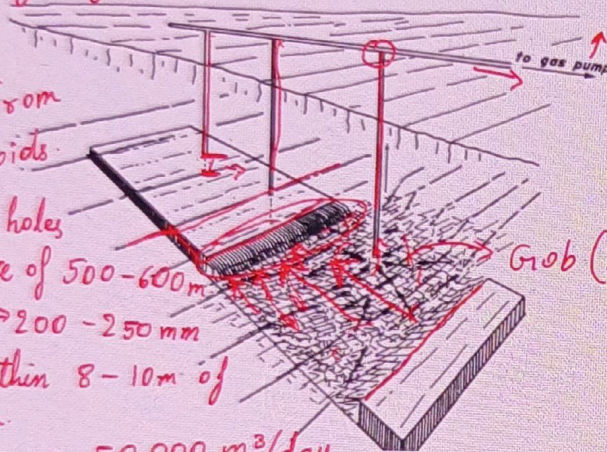
→ Gob gas
↓
taken out from
longwall voids.

→ Surface bore holes
at a distance of 500-600m

→ hole dia → 200-250 mm

→ Drilled within 8-10m of
Coal seam.

→ Gas per day → 50,000 m³/day.



- ① Direction of gas flow
- ② Purity of gas is maintained

Gob (Voids)

Fig. Gob drainage of a longwall panel

Cross Measure borehole Method.

→ Bore holes are drilled
in the tail gate
or return airway

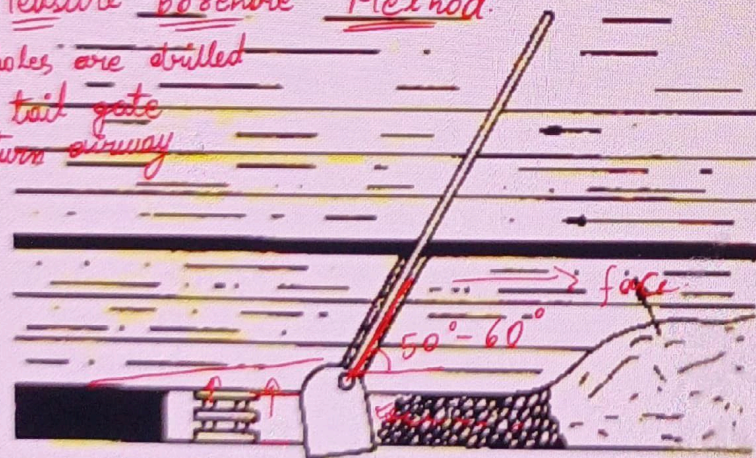


Fig. 1.2 Cross-measure borehole method of methane drainage.

→ hole dia → 65-90mm.

→ Distance b/w
Two holes is
20-30m.



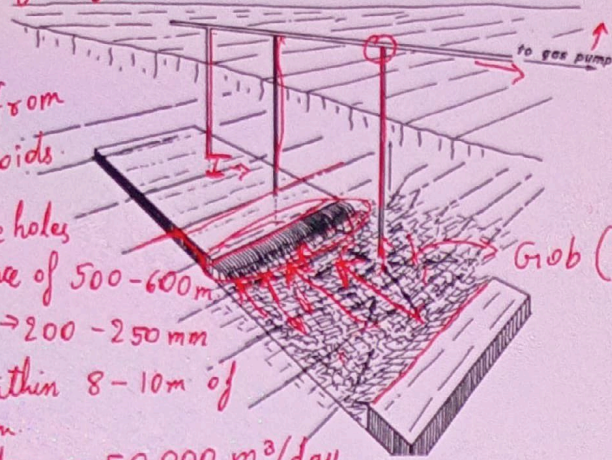
time (weeks)

b Drainage by surface boreholes.

Gob gas
↓
taken out from
longwall voids.

Surface bore holes
at a distance of 500-600m
hole dia $\rightarrow$ 200-250mm
Drilled within 8-10m of
Coal seam.

Gas per day $\rightarrow$ 50,000 m³/day.



- ① Direction of gas flow
- ② Purity of gas is maintained

Gob (voids)

Fig. Gob drainage of a longwall panel

Cross Measure borehole Method.

Bore holes are drilled
in the tail gate
or return airway

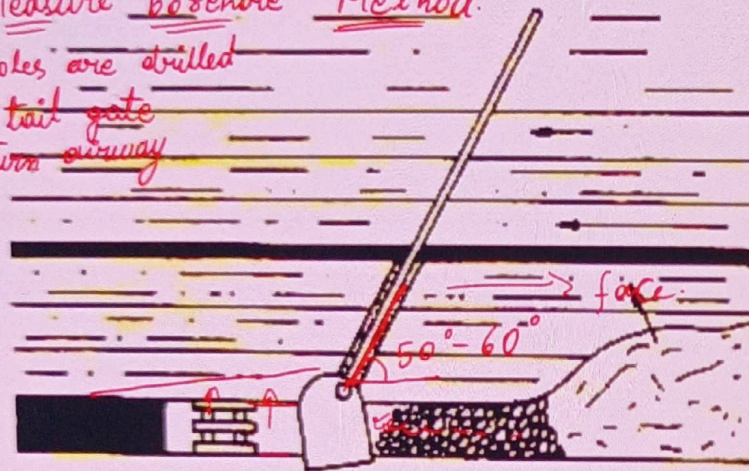


Fig. 1.2 Cross-measure borehole method of methane drainage.

hole dia $\rightarrow$ 65-90mm.

Distance b/w
Two holes is
20-30m.

Length of
hole $\rightarrow$ 15-100m.

it depends on
the adjacent gas bearing seams.

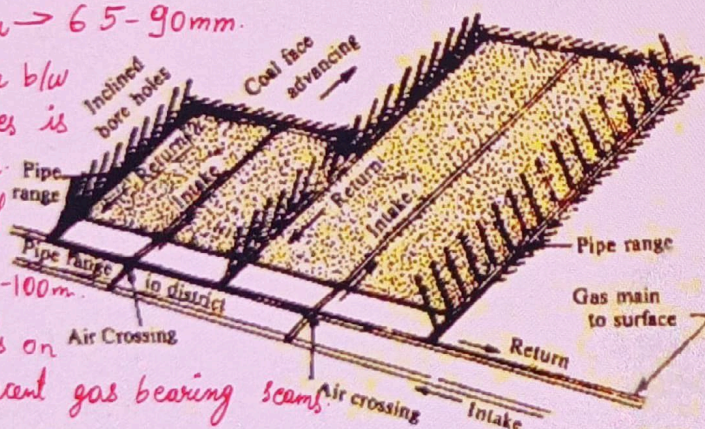
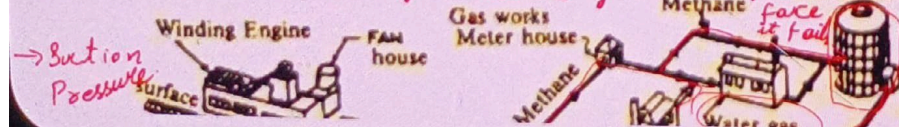


Fig. 1.15. Methane drainage (underground pipe system at a long wall face and layout of bore holes)

Drill mk $\rightarrow$ Nuss & Graffer Fortschritt PVI/6

Rate of Gas emission $\rightarrow$ Increases in First 2 weeks
after distance of 30-300m from Gas holder



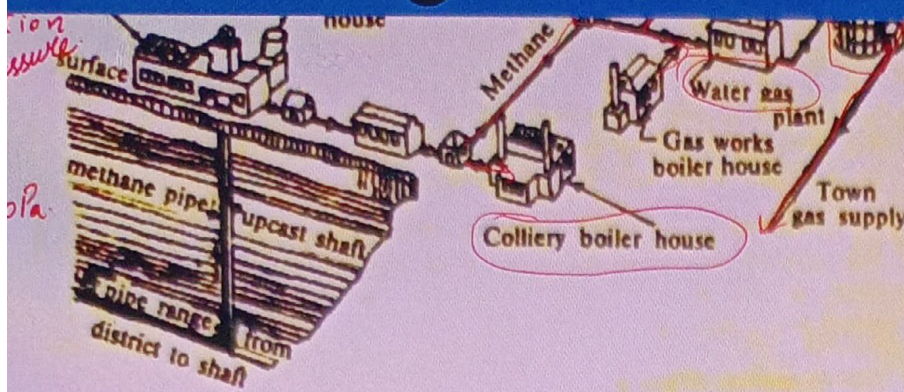


Fig. 1.16. Methane drainage; schematic layout at the surface

superjacent or Hirschbach Method.

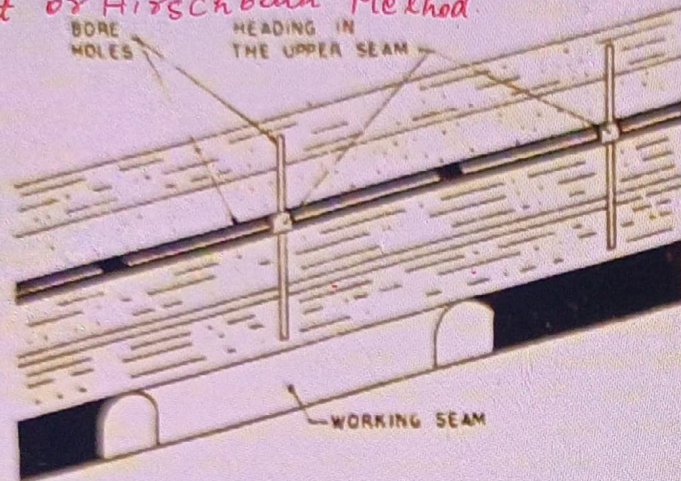


Fig. 1.3 Hirschbach method of methane drainage.

Applicable where an unworkable seam exists within 25 to 35m of the working.

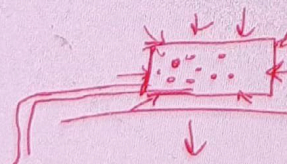
Headings of cross-sectional area 5-7 m² are driven at a height of about 25-30 m from the top of working seam.

→ Drive a heading of 0.3 - 0.4 m height.

Pack - Cavity method.

→ In this method corridors parallel to the face are left at intervals of 40m and within 20m from intake & return gate roads.

→ Pipe dia → 150 - 300 mm.





MINING GYAN

UG Mine Environment

By – Devendra Singh Tomar

Ventilation of a mine

- To restore the proper composition of mine atmosphere which should not contain less than 19% of oxygen or more than 0.5% of carbon-di-oxide.
- To dilute other noxious and inflammable gases like CO, CH₄ etc. so that they are harmless.
- A place is not considered to be free from firedamp if gas percentage is above 1.25.
- To provide good environmental conditions and to prevent excessive rise of temperature and humidity so that the workmen can work with maximum efficiency.
- The wet bulb temperature in development faces should not exceed 33.5°C.
- To remove or dissipate the coal or rock dust produced in the mine.

Quantity of air

- In gassy coal mines of deg. II & III the major consideration to decide the quantity of air going underground is the rate of emission of gas (firedamp) which should be so diluted by the ventilating air that its percentage is not more than 0.5 in the main return airway of the mine.
- Under the Coal Mines Regulations the standard of ventilation is as follows.
 - Quantity of air in a ventilating district should be
 - Minimum 6 m³/min. per person employed in the district on the largest shift.
 - More than 2.5 m³/min per tonne of daily output.
 - Underground air should not have less than 19% O₂
 - Underground air should not have more than 0.5% CO, or other noxious gases
 - Inflammable gas should be below 0.75% in the general body of return air of any ventilation district and below 1.25% at any place in the mine.
 - Wet bulb temperature should not exceed 33.5°C; if it exceeds 30.5°C at any place, air current should be faster than 1 m/s.
- Air samples and temperature readings shall be taken once in 30 days
- In deg. 2 and 3 mines quantity of air should be more than 8m³/min per person employed

should not contain less than 15% of oxygen or more than 0.5% of carbon-di-oxide.

- To dilute other noxious and inflammable gases like CO, CH₄ etc. so that they are harmless.
- A place is not considered to be free from firedamp if gas percentage is above 1.25.
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- In deg. 2 and 3 mines quantity of air should be more than 8m³/min per person employed

Gassiness degree (coal mines)	Per person in U/G mine	Per tonne of daily output
I	7m ³	3m ³
II & III	8 – 10m ³	4 – 5m ³

- On which basis quantity of air is decided?
- Ans – rate of emission of methane gas

Mine Ventilation Instruments

By – Devendra Singh Tomar



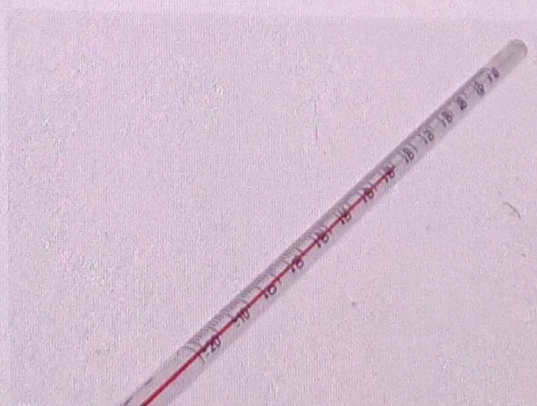
MINING GYAN

Mine ventilation instruments

- Thermometer
- Barometer
- Hygrometer
- Kata thermometer
- Air velocity meters
- Water gauge for mine fans
- Gas detectors

Thermometers

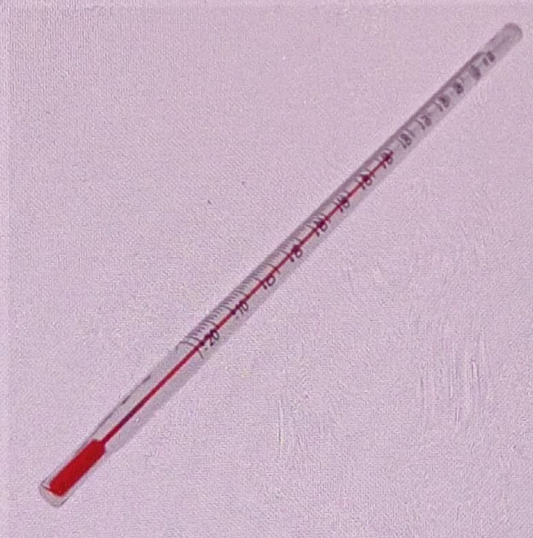
- SI unit for temperature measurement
- $F = 9/5 C + 32$
- Absolute zero – Theoretically the lowest possible temperature. It is the point at which all heat would be extracted from a substance if it can be cooled sufficiently. The absolute zero temperature is -273.15°C or -459°F



- Water gauge for mine fans
- Gas detectors

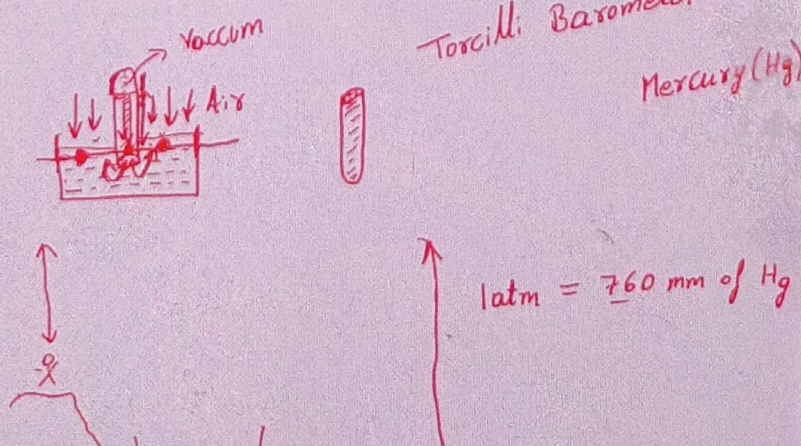
Thermometers

- SI unit for temperature measurement
- $F = \frac{9}{5} C + 32$
- Absolute zero – Theoretically the lowest possible temperature. It is the point at which all heat would be extracted from a substance if it can be cooled sufficiently. The absolute zero temperature is -273.15°C or -459°F



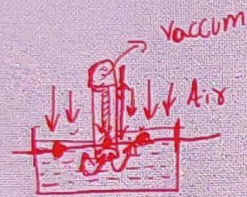
Barometer

- It is an instrument to measure the atmospheric pressure.
- The standard atmospheric pressure, also called the mean or normal atmospheric pressure, is defined as that pressure which supports a column of mercury 760mm high at the sea level when the temperature of the mercury is 0°C



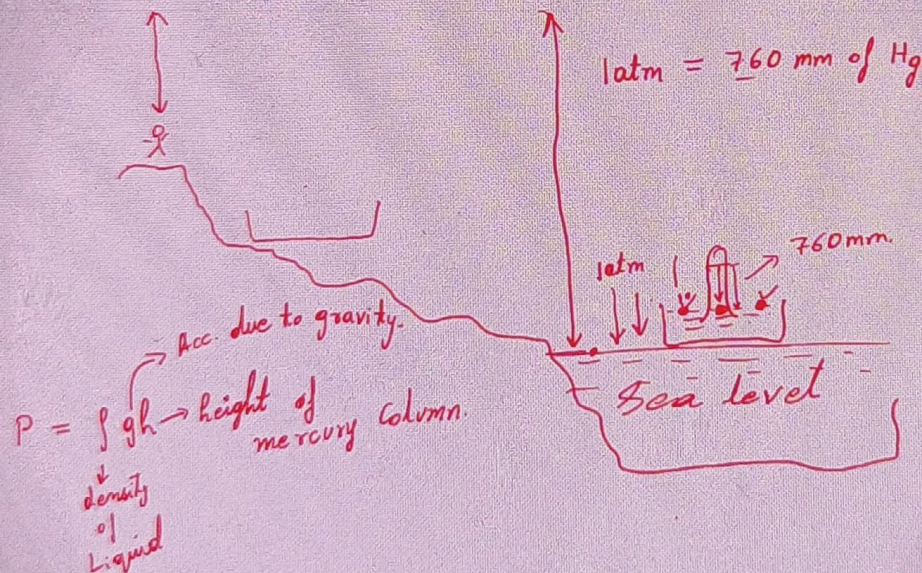
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Torricelli Barometer

Mercury (Hg)



$$P = \int \rho g h$$

Pressure at sea level.

$$h = 76 \text{ cm} \Rightarrow \frac{76}{100} \text{ m}$$

$$P = 13600 \times 10 \times \frac{76}{100}$$

$$\approx 1.01 \times 10^5 \text{ N/m}^2$$

$$= 1 \text{ atm}$$

h of mercury column $\rightarrow 70 \text{ cm}$.

$$P = 13600 \times 10 \times \frac{70}{100}$$

$$= 9.52 \times 10^4 \text{ N/m}^2$$

Mercury (Hg)

Density (ρ) = 13600

$\rightarrow$ It has highest density

$\rightarrow$ It is opaque & Shinning.

$\rightarrow$ It does not Vapourise.

$$P = 1.01 \times 10^5$$

$$\rho_w = 10^3$$

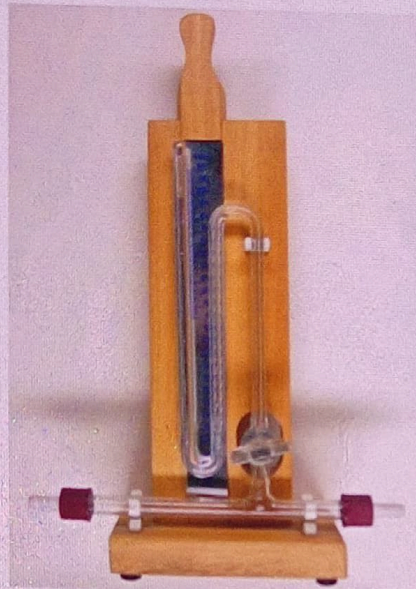
$$g = 10$$

$$h = ?$$

$$1.01 \times 10^5 = 10^3 \times 10 \times h$$

$$h = \frac{1.01 \times 10^5}{10^4}$$

$$= 1.01 \times 10$$



Fortin barometer

- It is used for the measurement of atmospheric pressure
- It consists of a straight glass tube about 920mm long and about 8mm inside diameter.
- It has two scales
 - Main scale
 - Vernier scale



Aneroid barometer

- It is better than mercury barometer.
- The term aneroid means that the instrument does not contain liquid.
- It works on the principle of Boyles law.
- It consists of a hollow, air tight, gas filled box made of thin springy

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- It has two scales
 - Main scale
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Aneroid barometer

- It is better than mercury barometer.
- The term aneroid means that the instrument does not contain liquid.
- It works on the principle of Boyles law.
- It consists of a hollow, air tight, gas filled box made of thin springy corrugated metal and prevented from collapsing by means of a strong flat spring.
- It measures pressure from 700m to 780mm of mercury
- The barometric pressure increases with depth below the sea level and decreases with height above sea level at a rate of nearly 1mm Hg difference for every 12m vertical difference
- The noxious and inflammable gases like methane in the goaf of a coal mine expand when there is a sudden drop in the barometric pressure and overflow into the mine workings.
- If the barometer is steady or rising, there is no overflow and no danger of fouling of the mine ventilating air current.





Humidity

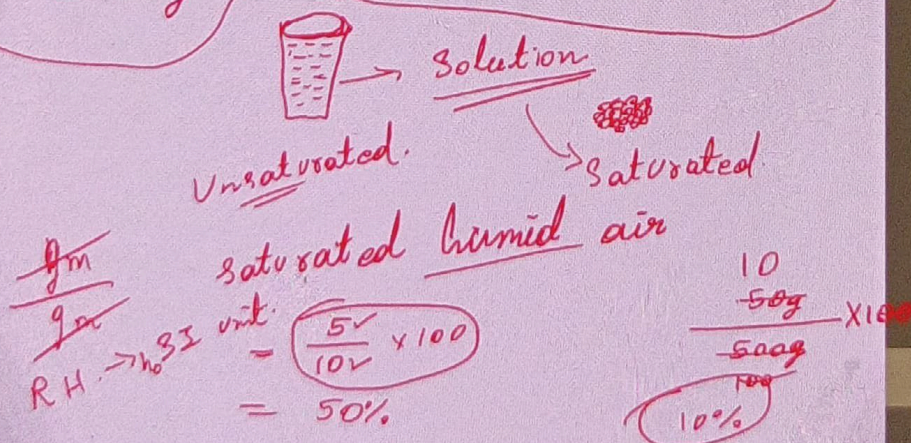
MINING GYAN

By – Devendra Singh Tomar

Hygrometer and relative humidity

- The atmospheric air has the capacity to absorb moisture and air containing it is called humid air.
- A given volume of moist air is lighter than the same volume of dry air.
- Under normal conditions air is never completely dry and the extent to which it is humid, is known as relative humidity.
- Relative humidity = $\frac{\text{mass of water vapour per m}^3 \text{ of air}}{\text{mass of water vapour required to saturate one m}^3 \text{ of air}}$
- The relative humidity of saturated air is 100%
- The percentage of saturation, except in arid regions, is rarely less than 35% and is higher near the sea shore

→ हुवा में कितनी moisture है उन्ही relative humidity.



→ Normal human body temperature is $98^\circ F$
 $36.6^\circ C$

→ Convert $100^\circ F$ into degree Celsius.

$$C = (F - 32) \times \frac{5}{9}$$

$$= (100 - 32) \times \frac{5}{9}$$

$$36 = (F - 32) \times \frac{5}{9}$$

$$\frac{36 \times 9}{5} = F - 32$$

Convert 100°F into degree Celsius.

$$\begin{aligned}
 C &= (F - 32) \times \frac{5}{9} \\
 &= (100 - 32) \times \frac{5}{9} \\
 &= 68 \times \frac{5}{9} \\
 &= \frac{340}{9} \\
 &= 37.77^\circ\text{C}
 \end{aligned}$$

$$36 = (F - 32) \times \frac{5}{9}$$

$$\frac{36 \times 9}{5} = F - 32$$

$$\frac{324}{5} = F - 32$$

$$64.8 = F - 32$$

$$F = 64.8 + 32 = 96.8$$

Perspiration → पसीना



→ To make the worker feel comfortable which type of air must flow in mine working

- ① Dry air ✓
- ② Wet air
- ③ Moist air

The quantity of moisture present in air is chiefly dependent on temperature and pressure, other things being equal

When a human works his body sweats

Normal human body temperature is 98°F i.e. 36.6°C

A person feels discomfort if the body temperature goes up or below 1°C

Cooling effects of air depends on

- Temperature
- Humidity
- Air velocity

Sources of moisture content in mine air

- Original moisture content of air
- Moisture given off from the strata in wet downcast shafts
- Wet roadways, working places and drains
- Perspiration of men
- Water vapour given off during burning of lamps
- Water introduced in the mine for wet cutting, water infusion, spraying on coal dust etc.

Questions

- On which factors quantity of moisture in air will depend?

Ans – temperature, pressure

- Cooling effects of mine air depends on which of the following?

Ans – temperature, humidity and air velocity

- Which of the following are the sources that contribute to the moisture content of mine air?

Ans – see slide 6 for answer

Humidity measuring instruments

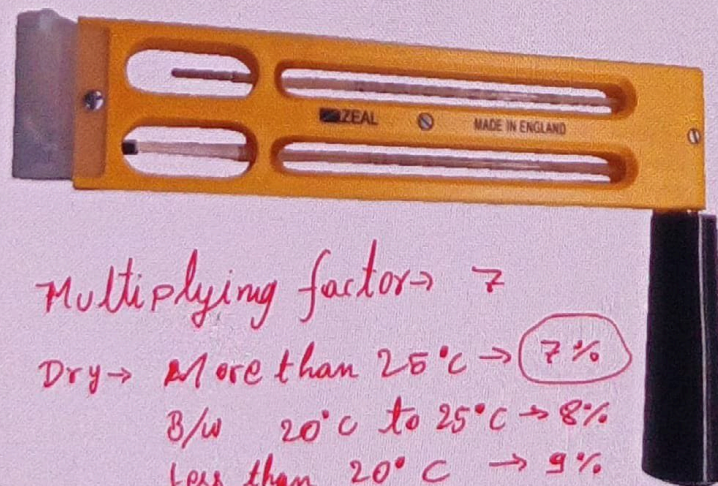
By – Devendra Singh Tomar



MINING GYAN

Hygrometer

- It is an instrument to determine relative humidity of air
- Basically it determines the extent to which mine air is saturated with moisture
- It has two thermometers mounted side by side on a wooden frame
- One thermometer is dry bulb and it indicates the actual temperature of the surrounding air
- The other thermometer is wet bulb covered with wet muslin cloth
- When the frame along with thermometers is whirled at 200 rpm for about 1 minute the readings of dry and wet bulbs change
- Formula
 - Relative humidity = $100 - (DBT - WBT) \times \text{Multiplying factor}$



Multiplying factor $\rightarrow 7$

Dry $\rightarrow$ More than $25^{\circ}\text{C} \rightarrow 7\%$
B/w 20°C to $25^{\circ}\text{C} \rightarrow 8\%$
less than $20^{\circ}\text{C} \rightarrow 9\%$

$DBT \rightarrow 23^{\circ}\text{C}$
 $WBT \rightarrow 19^{\circ}\text{C}$

$$\begin{aligned} RH &\Rightarrow 100 - (23 - 19) \times 8 \\ &= 100 - 4 \times 8 \\ &= 100 - 32 \\ &= 68\% \end{aligned}$$

$$= 68\%$$

$$\begin{aligned} \text{DBT} &\rightarrow 31^\circ\text{C} \\ \text{WBT} &\rightarrow 25^\circ\text{C} \end{aligned}$$

$$\begin{aligned} \text{RH} &\Rightarrow 100 - (31 - 25) \times 7 \\ &= 100 - 6 \times 7 \\ &= 100 - 42 \\ &= \underline{\underline{58\%}} \end{aligned}$$

$$\begin{aligned} \text{DBT} &\rightarrow 15^\circ\text{C} \\ \text{WBT} &\rightarrow 10^\circ\text{C} \end{aligned}$$

$$\begin{aligned} \text{RH} &\Rightarrow 100 - (15 - 10) \times 9 \\ &= 100 - 5 \times 9 \\ &= 100 - 45 \\ &= \underline{\underline{55\%}} \end{aligned}$$

- ① DBT $\rightarrow 35^\circ$ & WBT $\rightarrow 26^\circ\text{C}$
- ② DBT $\rightarrow 19^\circ$ & WBT $\rightarrow 11^\circ\text{C}$
- ③ DBT $\rightarrow 23^\circ$ & WBT $\rightarrow 15^\circ\text{C}$
- ④ DBT $\rightarrow 37^\circ$ & WBT $\rightarrow 30^\circ\text{C}$
- ⑤ DBT $\rightarrow 24^\circ$ & WBT $\rightarrow 17^\circ\text{C}$

- If the relative humidity of air is high and the air velocity is more, the combined effect is drying of the coal dust and creation of dusty condition in a coal mine.
- Moreover, high velocity of air causes discomfort to the workers.
- The velocity of air at the working face at 0.5 m to 2.0 m/s is reasonable for comfortable working conditions.
- In addition to these considerations the capacity of a worker to work in mines with humid conditions depends on the extent of his habit.
- An Indian worker may continue to work reasonably well in an underground atmosphere where the wet bulb temperature is 30°C or near about.
- The temperature and relative humidity of air increase in the vicinity of a place of spontaneous heating of coal
- If the hygrometer readings are taken regularly they provide an indication whether or not heating is taking place.

Kata thermometer

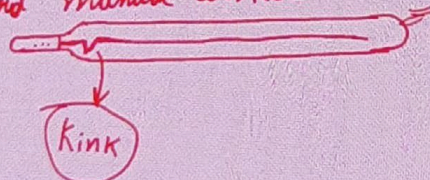
- To know the temperature of air at the working place, the relative humidity and air velocity.
- The joint effect of all these factors can be known with the help of kata thermometer which measures the cooling power by a combination of the above mentioned three factors at the instrument temperature of 36.5°C , the

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Kata thermometer

- To know the temperature of air at the working place, the relative humidity and air velocity.
- The joint effect of all these factors can be known with the help of kata thermometer which measures the cooling power by a combination of the above mentioned three factors at the instrument temperature of 36.5°C, the normal temperature of human body.
- Kata consists of an alcohol thermometer with two marks graduated on the stem at 35°C and 38°C.
- The instrument is used as follows:-
 - The bulb is immersed in hot water carried in a thermos flask until the alcohol rises above the upper graduation.
 - The bulb is wiped dry and the time required for the alcohol column to drop from the upper mark to the lower mark is noted.
 - The procedure is repeated with a wet muslin cloth wrapped on the bulb
 - An instrument factor is marked on every instrument.
 - The kata factor of an instrument is the number of milli calories of heat which it loses per sq. cm. of surface area of the bulb on cooling from 38° to 35°C. It is nearly 480.

For sedentary workers → 6 180
 For light manual workers → 8 240
 For hard manual workers → 10 300



Cooling Power = $\frac{\text{kata factor}}{\text{Time in sec. for alcohol to fall from upper mark to lower mark}}$
 SI unit → Millicalories per cm² per second.

Time in sec. from upper to lower. → 480

DBT → (1) 5 sec
 (2) 10 sec
 (3) 15 sec
 (4) 20 sec
 (5) 25 sec

WBT → 05 sec
 WBT → 10 sec
 (3) 15 sec
 (4) 20 sec
 (5) 30 sec

$$\textcircled{1} \quad CP = \frac{480}{5} = 96 \text{ mCal. / cm}^2/\text{sec.}$$

$$\textcircled{2} \quad CP = \frac{480}{30} = 16 \text{ mCal/cm}^2/\text{sec.}$$



MINING GYAN

Humidity & Pressure

By – Devendra Singh Tomar

Temperature & Humidity Monitor

- The Sieger model 111 monitor is an intrinsically safe, low cost device for continuously measuring the temperature and humidity in underground mines.
- The instrument consists of three units
 - a control module
 - a remotely sited transducer complete with sensors
 - a connecting cable, which can be up to 400 metres long
- A number of alternative power inputs can be used, including 12V DC, 18V DC, or 15V AC.
- Intrinsically safe supplies, all of which will also charge the inbuilt nickel cadmium battery.
- When used with an intrinsically safe power input a **Special Junction box** is used which prevents incorrect connection of the various leads.
- The transducer unit contains separate temperature and humidity sensor together with voltage regulation and signal conditioning circuits, power for which is obtained from the control module.
- These give continuously readings of both temperature ($^{\circ}\text{C}$) and humidity (in percentage RH), in addition to warning of low battery or fault conditions.

Measurement of air pressure

- The pressure of atmospheric air is measured by Fortin's barometer or aneroid barometer.
- A barometer records absolute pressure in mm of mercury column.
- It is maximum at the sea level and gradually decreases with altitude above sea level.
- The **standard atmospheric pressure**, also called the **mean or normal atmospheric pressure**, is defined as that pressure which supports a column of mercury 760mm high at sea level when the temperature of mercury is 0°C .
- In the metric units the value of standard atmospheric pressure is very nearly 1 kgf/cm .
- The internationally accepted value of standard atmospheric pressure in SI units is $101,325 \text{ N/m}^2$, i.e. approximately $100,000 \text{ N/m}^2$.
- The unit bar (b) used by the meteorologists to express atmospheric pressure is equivalent to 10^5 N/m^2 , and therefore very nearly equal to the atmospheric pressure.

Pressure at sea level

$$P = \rho gh$$

$$h = 76 \text{ cm} = \frac{76}{100} \text{ m}$$

$$P = 13600 \times 10 \times \frac{76}{100}$$

$$= 1.01 \times 10^5 \text{ N/m}^2$$

$$= 1 \text{ atm}$$

$$h = 65 \text{ cm} = \frac{65}{100}$$

$$P = 13600 \times 10 \times \frac{65}{100}$$

$$= 8.84 \times 10^4 \text{ N/m}^2$$

$$\textcircled{1} h = 60 \text{ cm}$$

$$\textcircled{2} h = 610 \text{ mm}$$

$$\textcircled{3} h = 560 \text{ mm}$$

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$$\textcircled{1} h = 60 \text{ cm}$$

$$\textcircled{2} h = 610 \text{ mm}$$

$$\textcircled{3} h = 560 \text{ mm}$$

$$\textcircled{4} h = 36 \text{ cm}$$

$$\textcircled{5} h = 460 \text{ mm}$$

At sea level $\rightarrow$ Height of mercury column is 760 mm.

$\Rightarrow$ what will be the height water column at sea level.

Ans $\rightarrow h = ?$, $\rho = 1000$, $g = 10$, 1.01×10^5

$$P = \rho gh$$

$$h = \frac{P}{\rho g}$$

$$= \frac{1.01 \times 10^5}{1000 \times 10}$$

$$= 1.01 \times 10$$

$$h = 10.1 \text{ m}$$

Air Velocity meters $\rightarrow$ Anemometer, velometer, pitot tube.

- Which type of cooling power is calculated by dry time
- Which type of cooling power is calculated by wet time
- Conduction
- Convection
- Radiation
- Ultra violet

Alcohol $\downarrow$
38°C
35°C

Cooling Power =

kata factor
Time

SI Unit $\Rightarrow \text{mCal./cm}^2/\text{sec.}$

- Pressures of fluids are measured by pressure gauges or manometers.
- A manometer measures small pressure differences above or below the atmospheric pressure.
- It consists of a vertical U-tube containing a liquid and one limb of the U-tube is connected to the vessel containing the fluid under pressure while

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- A manometer measures small pressure differences above or below the atmospheric pressure.
- It consists of a vertical U-tube containing a liquid and one limb of the U-tube is connected to the vessel containing the fluid under pressure while the other limb is open to the atmospheric air.
- The liquid in the U-tube is generally mercury but if the pressure difference is small, water or other lighter liquid is used.
- The difference between the levels of the liquid in the two vertical limbs of the U-tube is a measure of the pressure of the fluid above or below the atmospheric pressure.
- If the prevailing atmospheric pressure is P mm of mercury and if the liquid used in the manometer is mercury, the absolute pressure of fluid in the cylinder at b is $P + h$ mm of mercury and at c , it is $P - h$ mm of mercury.

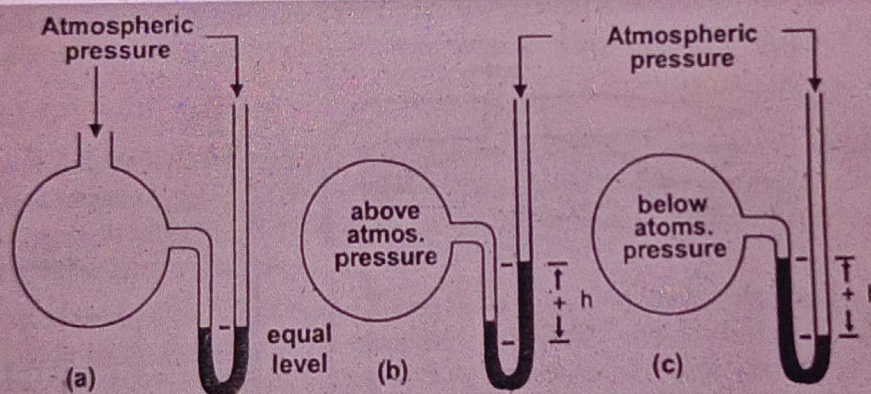


Fig. 2.4

- The amount by which a pressure is below the prevailing atmospheric pressure is referred to as vacuum and it is quoted in mm of mercury or water column.
- Absolute pressure = prevailing atmospheric pressure + gauge pressure
- The minus sign is to be used when the pressure gauge records vacuum. Such pressure gauge recording vacuum is called a vacuum gauge.
- If a manometer employed for finding out the pressure of a fluid uses water in place of mercury and the difference of water levels in the two limbs of U tube is h mm
- Absolute pressure in mm of Hg = $\frac{\text{Barometric height of water column in mm} + h}{13.6}$
- The pressure developed by a mine fan is small and it is measured by a manometer using water.
- If very small pressure differences are to be measured, 50mm of water, inclined manometers are used in which the limbs of the U tube are inclined to the horizontal.

① Calculate the absolute pressure in manometer if height of mercury column decreases by 30mm.

$$\begin{aligned}
 P &= 1.01 \times 10^5 - \frac{30 \text{ mm}}{1000} \\
 &= 1.01 \times 10^5 - 0.03 \text{ m} \\
 &= 0.98 \times 10^5 \text{ N/m}^2
 \end{aligned}$$

- The minus sign is to be used when the pressure gauge records vacuum. Such pressure gauge recording vacuum is called a vacuum gauge.
- If a manometer employed for finding out the pressure of a fluid uses water in place of mercury and the difference of water levels in the two limbs of U tube is h mm
- Absolute pressure in mm of Hg = $\frac{\text{Barometric height of water column in mm} + h}{13.6}$
- The pressure developed by a mine fan is small and it is measured by a manometer using water.
- If very small pressure differences are to be measured, 50mm of water, inclined manometers are used in which the limbs of the U tube are inclined to the horizontal.

1) Calculate the absolute pressure in manometer if height of mercury column decreases by 30mm.

$$\begin{aligned}
 P &= 1.01 \times 10^5 - \frac{30 \text{ mm}}{1000} \\
 &= 1.01 \times 10^5 - 0.03 \text{ m} \\
 &= 0.98 \times 10^5 \text{ N/m}^2
 \end{aligned}$$

GP-720

① Static Pressure → Pressure exerted by moving fluid on a parallel surface.

② Velocity Pressure → Pressure exerted by moving fluid due to its velocity.

③ Total Pressure → Static Pressure + Velocity Pressure
(fan Pressure)

Motive Column & NVP.

Motive Column

$$h = \frac{T_u - T_d}{273 + T_u} \times D.$$

NVP ⇒ Motive Column $\times$ Density of air
DC slugs



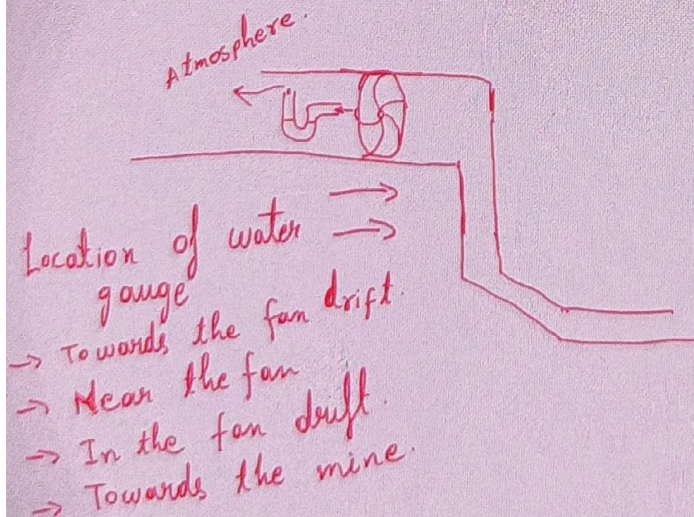
MINING GYAN

Measurement of ventilating pressure

By – Devendra Singh Tomar

Water gauge

- The atmospheric pressure in an underground mine can be measured by the aneroid barometer
 - It has a U shaped glass tube one open end connected to point of low pressure and another end to point of high pressure
 - The difference between the water levels of the two legs of the U tube record the pressure difference between two points
 - A difference of 1mm represents a pressure difference of 1kgf/m^2
 - Water gauge is placed in the fan draft, one end connected to the atmosphere and the other in the fan drift very near to the fan i.e. towards mine
- what must be the location of water gauge to measure mine atmospheric pressure?*



Pressure terminologies

- **Static pressure** – The pressure exerted by a moving fluid on a surface parallel with the direction of movement
- **Velocity pressure** – The pressure exerted by fluid by virtue of its motion and it varies with the square of its velocity
- **Total pressure** – This is the algebraic sum of velocity pressure and static pressure

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Total pressure

- In case of fan it is also known as fan pressure or ventilating pressure
- Fan pressure is the difference between the mean total pressure of the fan and the mean total pressure of the air entering the fan
- For the fan located on the surface it is the difference between the atmospheric pressure and the total pressure in the fan drift.
- It is measured by a facing tube i.e. with the open end of the tube facing upstream side of air current

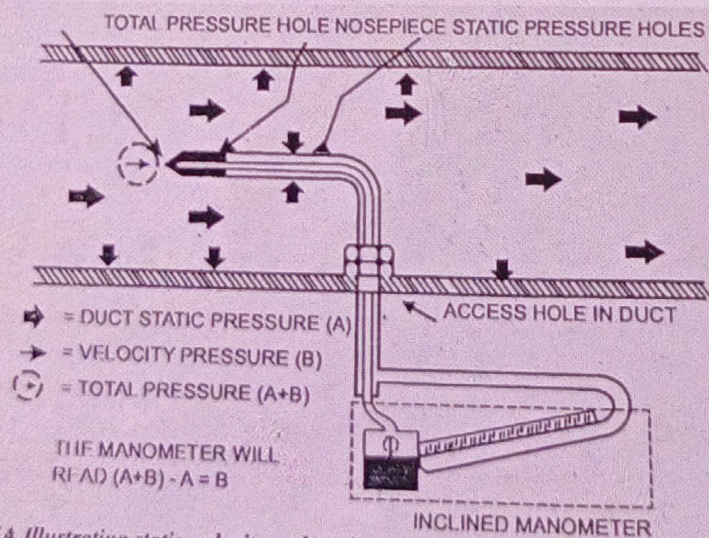


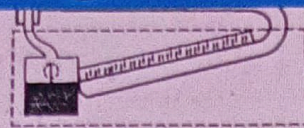
Fig. 2.5A Illustrating static, velocity and total pressure and use of an inclined manometer

Measurement of fan pressure

- A – The tube projects into the drift at right angles to the direction of air flow and is provided with a thin, sharp edged flat disc called D Arc tip
- B – A recess is cut in the side of the drift and is closed by a smooth metal plate fitted flush with the drift side and perforated with a small hole
- C – Hooked tube sealed at the point and provided with four small holes without burr. It gives maximum reading when correctly aligned in the air current.

(*) = TOTAL PRESSURE (A+B)

THE MANOMETER WILL
READ (A+B) - A = B

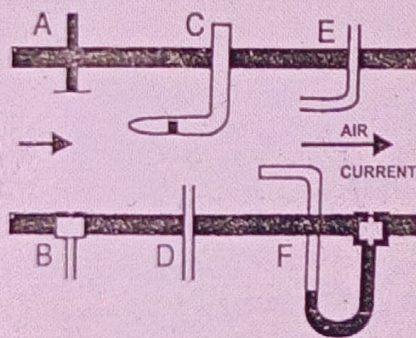


INCLINED MANOMETER

Fig. 2.5A Illustrating static, velocity and total pressure and use of an inclined manometer

Measurement of fan pressure

- A – The tube projects into the drift at right angles to the direction of air flow and is provided with a thin, sharp edged flat disc called D Arc tip
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- C – Hooked tube sealed at the point and provided with four small holes without burr. It gives maximum reading when correctly aligned in the air current.
- D – Gives incorrect results too low reading with the compressing fan and too high with an exhausting fan



A, B and C give static pressure,
D – not recommended
E – gives total pressure or fan pressure

- E – It is this pressure that must always be used:-
 - When calculating the HP in the air
 - When determining the efficiency of fan
 - To measure average static pressure
- Water gauge produced by fans is between 25mm and 150mm, it is higher for deep mines
- In UG auxiliary fans or booster fans very small water gauge is measured by U tube with inclined limbs
- To measure the water gauge smaller than 50mm an inclined water gauge is generally used
- Vertical w.g. = $L \times \sin \alpha$
 - Where α is the angle of inclination with the horizontal and L the inclined reading of manometer
 - The manometer can be made more sensitive by using a lighter liquid instead of water e.g. alcohol
- Vertical w.g. = $L \times \sin \alpha \times w$
 - Where w is the specific gravity of the liquid
 - The inclination of the water gauge is conveniently adjusted to $5^\circ 44'$ as the sine of that angle is 0.1
- Inclined water gauge can be read upto 0.2mm and in some cases even upto 0.02mm depending upon scale graduation

what is the purpose of measuring fan pressure?

which of the following pressures are measured by VO to determine the efficiency?



1 atm = 760 mm of Hg.

which type of water gauge must be used for small water gauge differences?

→ inclined water gauge / Inclined manometer.

1 atm = 760 mm of Hg.
 Which type of water gauge must be used for small water gauge differences?
 → Inclined water gauge / Inclined manometer.

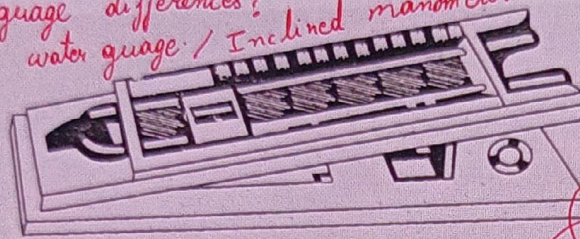
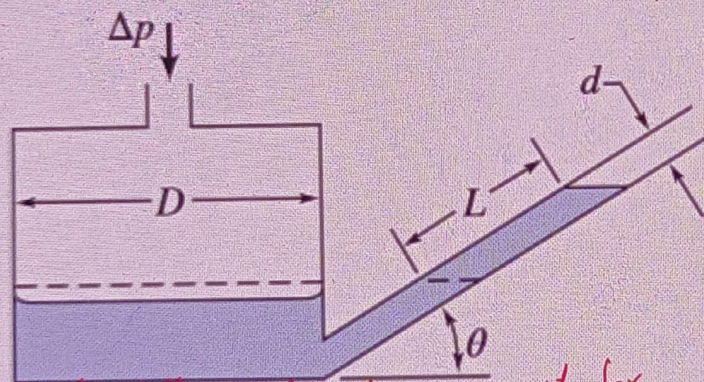
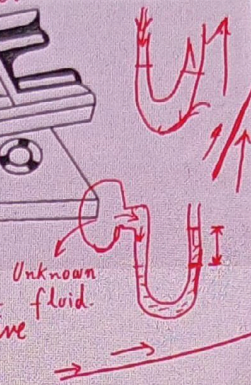


Fig. 2.6 Inclined manometer

→ Which type of liquid must be used in manometer for making it sensitive?
 Ans → Lighter liquid / Alcohol / Petrol.



Which of the following formulae is correct for measuring Vertical Wg.?

Pitot Tube

- It is a device used to measure the static pressure, velocity pressure or the total pressure
- One leg utilised to obtain the static pressure and the other to obtain the total pressure, the actual reading recording the velocity pressure which is equal to the difference between the limbs of the U-tube
- If the velocity pressure of air at any point has to be measured the two limbs.

$$V = 4.43 \sqrt{\frac{W \cdot g}{W}}$$

V = Velocity of air in m/sec.

Wg ⇒ Pressure in mm

W = Density of air in kgf/m^3

$$V = 4.015 \sqrt{W \cdot g}$$

$$V = 4.43 \sqrt{\frac{W \cdot g}{W}}$$

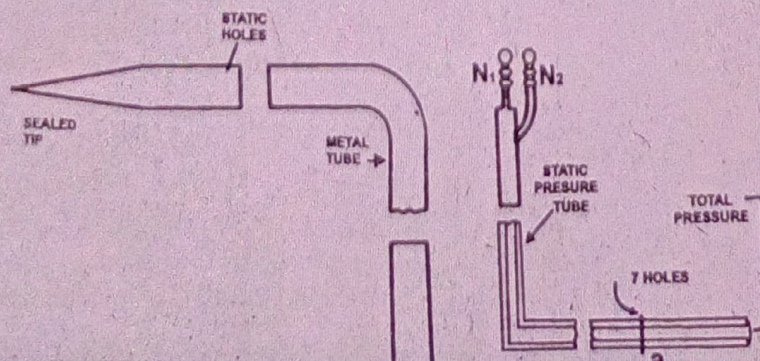
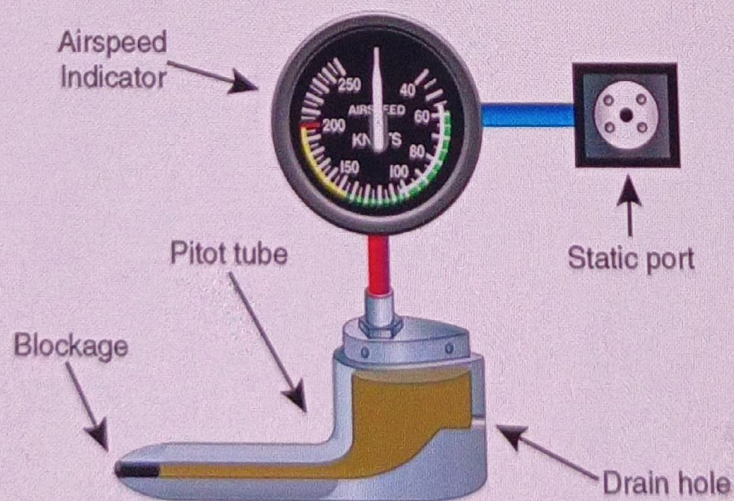
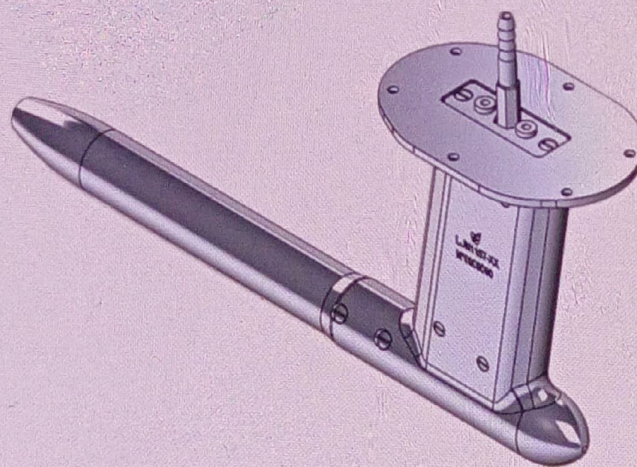
V = Velocity of air in m/sec.

$Wg \Rightarrow$ Pressure in mm

W = Density of air in kgf/m^3

$$V = 4.015 \sqrt{W \cdot g}$$

$$V = 4 \sqrt{Wg} \text{ (approximately)}$$



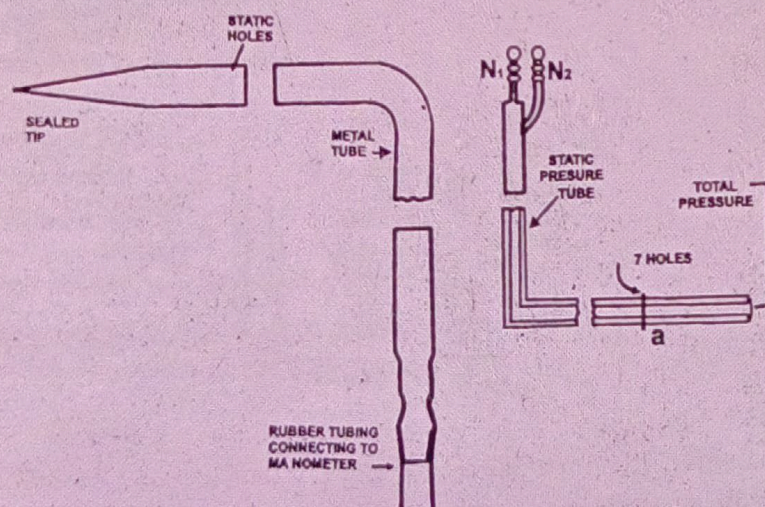
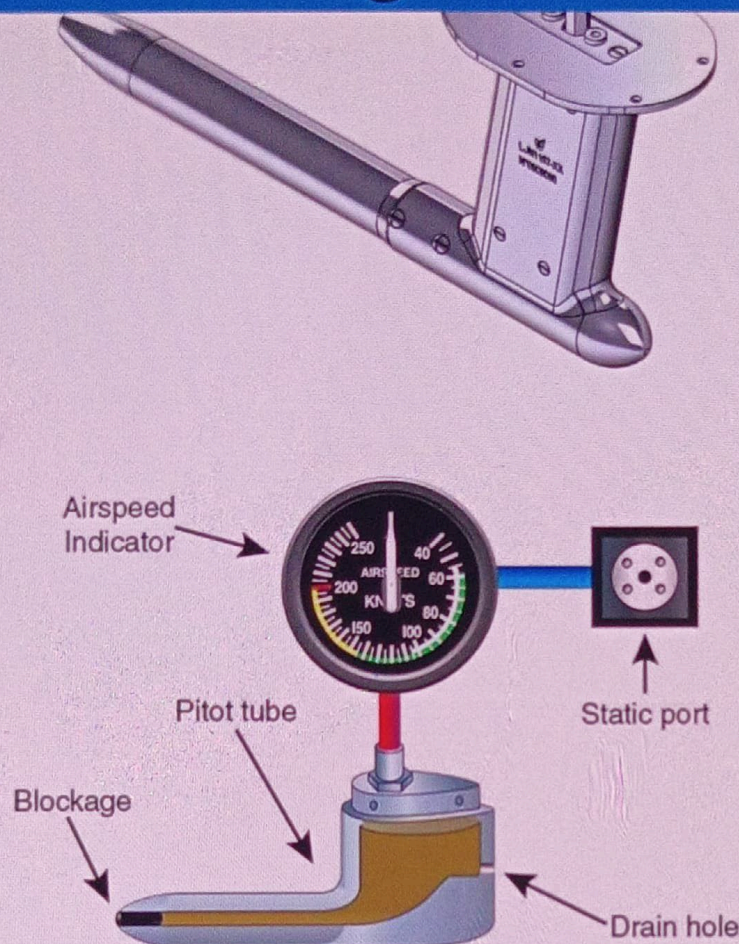


Fig. 2.7 Pitot tube

Portable inclined manometer

- Ordinary U – tube manometers are not useful for measurement of gas velocities below 12m/s, for this inclined tube manometer is preferred
- NMC inclined manometer can be swivelled in 4 positions – 1 in 20, 1 in 10, 1 in 5 and vertical.
- Maximum limit of pressure measurement is 250mm Wg
- Flexible PVC connecting tubing in contrasting colours, each of 9m length is provided
- Pressure range:- 0 – 125/250/500/2500 Pascals and 0 – 12.5/25/50/250 mm wg
- Velocity range:- 0 – 14.2, 0 – 28 m/sec

To which of the following positions inclined manometer can be used.



MINING GYAN

Natural Ventilation

By – Devendra Singh Tomar

Production of ventilation

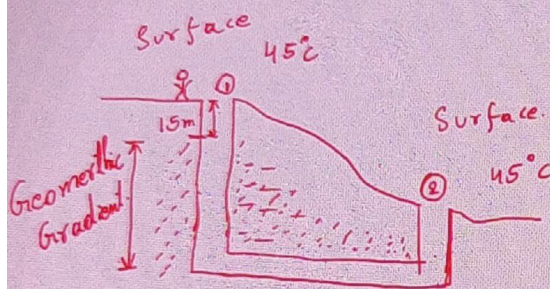
- Air always flows from a region of high pressure to low pressure
- The difference of pressure may be caused by
 - Purely natural means also known as natural ventilation
 - By fan also known as mechanical ventilation

what are the causes of pressure difference?
which vent. occurs by natural means?
which vent. occurs due to fan?
Air always flow from _____ to _____ region.

Natural ventilation

- If the air in both the shafts is at the same temperature and pressure, there are two columns of air equal in weight which balance each other and there will be no flow of air from one shaft to the other
- If the density of air in one shaft is more, the column of air in that shaft will have a higher weight and the difference in pressure at the bottoms of the shafts will cause flow of air from high pressure shaft to low pressure shaft
- The difference in density between two shafts may be produced by any of the following factors
 - Presence of firedamp or steam purposely introduced in one of the shafts which renders the air lighter
 - Presence of fire in one of the shafts. The fire heats up the air which has then less density
 - Passage of cold water down one of the shafts the cold air is more dense
 - Unequal depth of shafts
- The temperature of the rocks belowground is not the same as the temperature at the surface.

- shafts which renders the air lighter
 - Presence of fire in one of the shafts. The fire heats up the air which has then less density
 - Passage of cold water down one of the shafts the cold air is more dense
 - Unequal depth of shafts
 - The temperature of the rocks belowground is not the same as the temperature at the surface.
 - The day to day variation and the seasonal variation in atmospheric temperature affects only the rocks near the surface but whatever be the surface temperature at 15m below ground the temperature of rocks is constant
- which of the following are the factors of density difference!*



Natural Ventⁿ depends on

- Pressure difference
- Density of air.
- Temperature of air
- ↳ Geothermic gradient.
- Surface temp.

1°C → at a particular depth

Geothermic gradient

- Beyond depth of 15m the temperature of the rocks increases with depth at a definite rate known as Geothermic gradient and varies in different areas
- The constant temperature line at 15m below the surface and it is always parallel to the surface contour
- Below that line the air in the shafts gets heated mainly due to conduction of heat from the strata
- The natural ventilation causes the mine air to travel in opposite direction in summer and in winter
- In deep mines the air will travel in the same direction throughout the year provided the constant mean temperature of the air in the upcast shaft is higher than in the downcast shaft

Due to which reason density difference occurs in VC & DC shaft?

NVP

- Flow of air through mine workings by purely natural means is called natural ventilation
- Such flows takes place when there is a natural difference in densities between upcast and downcast shafts
- The heavier air sink down and lighter air moves up setting an air current
- The difference in densities may be due to difference in temperature, moisture, gas content etc.
- When the temperature difference of the two air columns is maximum the NVP is maximum and it ceases altogether when there is no temperature difference
- The two air columns should be considered between two imaginary planes, one at the shaft collar of the higher level shaft and the other at the lower point of the two shafts
- Total NVP can be calculated considering the two air columns stationary

NVP calculation from air density

- Natural ventilation pressure in a mine is the difference in pressure of air column in the downcast shaft and upcast shaft
- $NVP = P_1 - P_2 = D\rho_d g - D\rho_u g$
- Where
 - D = depth of downcast shaft (m)
 - g = acceleration due to gravity (m/s^2)
 - ρ_d = mean density of air in downcast shaft (kg/m^3)
 - ρ_u = mean density of air in upcast shaft (kg/m^3)

> Density of air changes with temperature.

Moisture का effect बहुत ही minor होता है

Density of air in DC shaft

$$\rho_d = \frac{B_d \times 10^3}{287.1 T_d} \text{ kg/m}^3$$

B_u & B_d are barometric Pressure (KPa)

Density of air in UC shaft

$$\rho_u = \frac{B_u \times 10^3}{287.1 T_u} \text{ kg/m}^3$$

where, T_u = avg. temperature in UC shaft (K)
 T_d = " " " " DC shaft (K)

$$NVP = P_1 - P_2$$

Note → for mine shafts $B_u = B_d = B$

$$= Dg\rho_d - Dg\rho_u$$

$$= Dg[\rho_d - \rho_u]$$

$$= Dg \left[\frac{B}{287.1 T_d} - \frac{B}{287.1 T_u} \right] \times 10^3$$

$$NVP = \frac{DgB}{287.1} \left[\frac{T_u - T_d}{T_u \cdot T_d} \right] \times 10^3 \text{ Pa.}$$

$$B = 101.33 \text{ KPa.}$$

Motive column → To represent Pressure in terms of height

- In the case of NVP the weight of air in DC air column which gives rise to the NVP
- The height of this weight of air column of DC shaft $1m^2$ in cross section which gives rise to NVP is called motive column

$$\frac{NVP}{287.1} = \frac{T_u - T_d}{T_u \cdot T_d}$$

$$P = 101.33 \text{ KPa}$$

Motive column $\rightarrow$ To represent pressure in terms of height or m

- In the case of NVP the weight of air in DC air column which gives rise to the NVP
- The height of this weight of air column of DC shaft 1m^2 in cross section which gives rise to NVP is called motive column

SI Unit = metre (m)

$$\text{Motive Column, } h = \frac{NVP}{\rho_d \times g}$$

$$h = \frac{g D B}{287.1} \left(\frac{T_u - T_d}{T_u \times T_d} \right) \times 10^3 \div \rho_d g$$

$$= \frac{g D B}{287.1} \left(\frac{T_u - T_d}{T_u \times T_d} \right) \times 10^3 \div \frac{B d \times 10^3 \times g}{287.1 T_u}$$

$$h = \frac{T_u - T_d}{T_u} \times D$$

Air Temp. in DC & UC shafts 465m deep is 30°C & 37°C resp. Calculate height of motive column. Find out the density of DC air & the amount of NVP.

$$\text{Sol.}^n \Rightarrow T_d = 30 + 273 = 303 \text{ K}$$

$$T_u = 37 + 273 = 310 \text{ K}$$

$$h = \frac{310 - 303}{310} \times 465$$

$$h = 10.5 \text{ m}$$

$$\rho_d = \frac{B d \times 10^3}{287.1 \times T_d}$$

$$= \frac{101.33 \times 10^3}{287.1 \times 303}$$

$$NVP = \frac{D g B}{287.1} \left(\frac{T_u - T_d}{T_u T_d} \right) \times 10^3 \text{ KPa}$$

$$= \frac{465 \times 101.33}{287.1} \left(\frac{310 - 303}{310 \times 303} \right) \times 10^3$$

& the amount of NVP.

$$\text{Sol.}^n \Rightarrow T_d = 30 + 273 = 303 \text{ K}$$

$$T_u = 37 + 273 = 310 \text{ K}$$

$$h = \frac{310 - 303}{310} \times 465$$

$$h = 10.5 \text{ m}$$

$$\rho_d = \frac{\rho_d \times 10^3}{287.1 \times T_d}$$

$$= \frac{101.33 \times 10^3}{287.1 \times 303}$$

$$= 1.165 \text{ Kg/m}^3$$

$$\text{NVP} = \frac{D_g B}{287.1} \left(\frac{T_u - T_d}{T_u T_d} \right) \times 10^3 \text{ KPa}$$

$$= \frac{465 \times 101.33}{287.1} \left(\frac{310 - 303}{310 \times 303} \right) \times 10^3$$

$$= 164118.59 \times \frac{7}{93930} \times 10^3$$

$$h = \frac{\text{NVP}}{\rho_d g} \Rightarrow \text{NVP} = h \times \rho_d \times g$$

$$= 1.165 \times 10.5 \times 10 = 122.31 \text{ KPa}$$

$$= 122.325 \text{ KPa}$$

Causes of heating of air

- Conduction of heat from the strata
- Compression of the air due to depth in the DC shaft and dip working
- Burning of lamps
- Oxidation of carbonaceous material
- Heat given out by men
- Heat given out by machinery and subsiding strata

Causes of cooling air

- Evaporation of moisture from wet shafts and roadways or from coal itself
- Expansion of the air as it rises up the UC shaft or up the rising roadways to a higher level
- Local cooling effect due to expansion of compressed air at the exhaust of compressed air motors

**MINING GYAN**

Fan ventilation

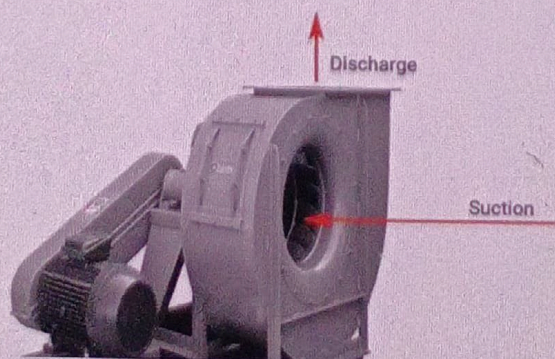
By – Devendra Singh Tomar

Fan ventilation

- Artificial ventilation is produced in a mine by fans
- It can be forcing fan or exhausting fan
- Main fan shall be situated on the surface
 - To not easily get affected by UG explosion
 - Easily accessible for supervision and maintenance
 - Shall be capable of reversing the ventilation
 - It shall have two independent electric circuits for power supply
- Types of fan used
 - Centrifugal fan
 - Air screw or axial flow fan

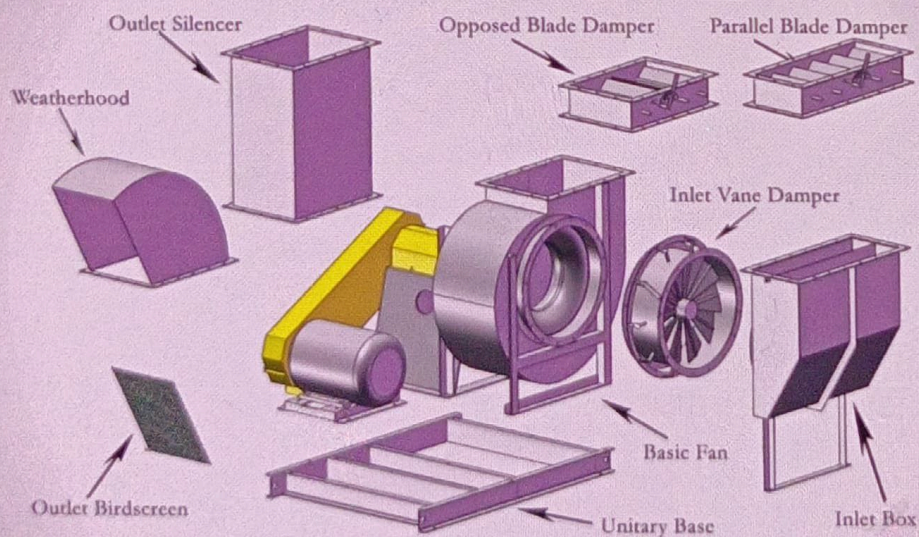
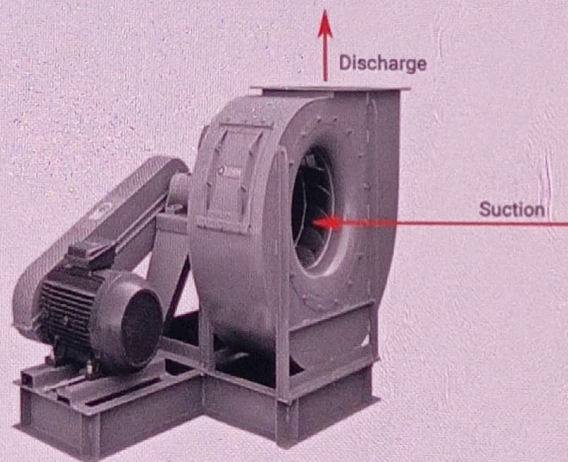
Centrifugal fan

- It consist of wheel carrying blades or vanes
- There is suction effect at the centre of the fan wheel where air enters to take place of the air driven out at the periphery
- The of the fan varies from 100 – 300 rpm
- The blades of fan are not exactly radial but either curved backward or curved forward though the backward curved blade types are common



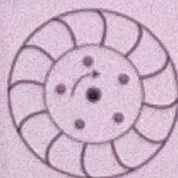
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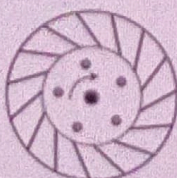


On which Principle Centrifugal fan works?

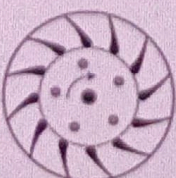
- ① Centrifugal effect
- ② Deflection effect.



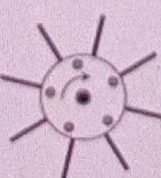
Backward curved blades



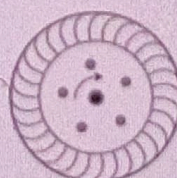
Backward inclined blades



Backward inclined aerofoil blades



Radial blades



Forward curved blades

Sirocco fan

Sirocco fan is which type of fan?

- It is a common type of centrifugal fan
- The fan wheel is cylindrically having 64 blades in single inlet and 128 blades in a double inlet fan
- The blades are nearly 160mm deep and are cup shaped
- The purpose of the spiral casing is to enclose the fan wheel and prevent re-entry of the discharged air
- The cross sectional area of the spiral casing gradually increases to accommodate the progressive increase in the quantity of air discharged by the fan wheel
- The evasee is provided to reduce the final velocity of the discharge to a minimum. This helps smooth flow of air and converts some final velocity energy into pressure energy
- Water gauge reduces saving the power
- A well designed evasee increases the efficiency of the fan and reduces cost of power for a given quantity of air

which of the following increases the efficiency of fan?

Air screw fan

water guage & quantity of air in an air screw fan depends on which thing?

- They push the air forward in the direction parallel to the axis i.e. axially without changing the direction of air current unlike in the centrifugal fan
- As the shaft and the blades mounted rotate, the air, because of the shape of the blades is pushed axially i.e. in line parallel to the fan shaft so that on one side of the blades the air under pressure and on the other side under suction
- It works on the principle of aerodynamic principle
- Blades of aeroplanes work on this principle
- The water gauge developed and quantity circulated depend on the speed of the blade tips and it has higher peripheral speed than centrifugal fan for the same water gauge
- High peripheral speed creates noise
- For fans near residential areas the permitted limit of the speed of blade tips is 4200m/min

At this speed the pressure may be 12.5cm of water gauge what is the speed of blade tips near residential areas?

Axial flow fan

which of the following depend on angle of fan blades?

- It consists of a rotor carrying a number of blades
- The angle or pitch of blade can be varied by 10° to 15° in either direction from the normal setting and the hub on the shaft is marked suitable to indicate the pitch
- By varying the pitch of the blades, the quantity of air circulated can be varied but pressure generated remains the same
- The water gauge can be increased by fixing two or more stages on the fan shaft if the fan is designed for it
- The water gauge developed per stage rarely exceeds 130mm

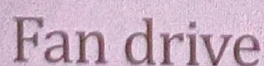
Evasée



- At this speed the pressure may be 12.5 cm of water gauge
what is the ^{max} speed of blade tips near residential areas?

Which of the following depend on angle of fan blades?

-
- The diagram illustrates a dust extraction system. A 'Fan house' is connected to an 'Upcast shaft', which has a red arrow indicating upward airflow. The shaft leads to a 'Fan' mounted on a 'Support'. The fan is connected to a 'Fan motor'. The fan draws air from a machine tool, labeled 'Evasée', which has a red arrow indicating upward airflow into the fan.



- 70/295

Instant Tube Manometer	
Velocity Reading (m/s)	0.00
Velocity Reading (ft/min)	0.00
Static pressure (Pa)	129.85
Avg Velocity (m/s)	12.47
Quantity of Air	1.000

Fan drive

- An electric motor is practically the standard driving arrangement for fans which have to run continuously
- The speed of fan can be varied by changing the gearing ratio of the driving pulleys
- In a coal mine nearly 5 tonne of air has to be sent down a mine for every tonne of coal raised

Air velocity

Air velocity at the working face should be between 0.5 to 2m/s

Carbide lamps can withstand an air velocity of 5m/s but it should not exceed 2.5m/s

Modern flame safety lamps can withstand an air velocity of 15m/s

Air velocity at the should not exceed

- Face - 1.7m/s
- Conveyor belt, loading and transfer points – 3m/s
- Main haulage roads – 5m/s
- Smooth lined airways not used for haulage and shaft with guide ropes – 7.5m/s
- Shaft with rigid guide ropes and fan drifts – 12.5m/s
- Diesel locomotive sheds and battery charging stations – not less than 0.75m/s

Control of quality of air delivered

- By removing some blades
- By changing the pitch of the blades on the hub of the rotor shaft
- By installing two or more stages on the shaft
- By changing the fan speed
- By placing air regulating dampers in the fan drift to reduce the quantity immediately in case of emergency
- By a controlled leakage via surface airlock
- By changing the mine resistance by installing air regulators
- By replacing the fan

Air screw v/s centrifugal fan

- An air screw requires less space in installation
- Reversal of air can be achieved by screw fans

- An electric motor is practically the standard driving arrangement for fans which have to run continuously
- The speed of fan can be varied by changing the gearing ratio of the driving pulleys
- In a coal mine nearly 5 tonne of air has to be sent down a mine for every tonne of coal raised

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- By placing air regulating dampers in the fan drift to reduce the quantity immediately in case of emergency
- By a controlled leakage via surface airlock
- By changing the mine resistance by installing air regulators
- By replacing the fan

Air screw v/s centrifugal fan

- An air screw requires less space in installation
- Reversal of air can be achieved by screw fans
- Both have higher efficiency than axial flow fan
- By air screw quantity of air can be varied and in case of centrifugal it can be achieved by using backward curved blades
- The air screw fan is noisy at high speeds of the blades
- Air screw has low water gauge and centrifugal fan more suited for high pressure and volume
- Air screw can develop high water gauge
- Air is best as a booster fan due to ease of installation and space requirement



MINING GYAN

Mine Fans

By – Devendra Singh Tomar

Forcing V/S Exhaust fans

- A forcing fan requires an airlock at the DC shafts but an exhaust fan has to be provided with an airlock at the UC shaft
- The pressure of forcing fan has the effect of keeping the gases of the goaf and old workings confined to their places
- If the fan stops or breaks down the air pressure in the mine falls to normal atmospheric pressure and the gases and old workings expand and overflow into the mine workings
- A forcing fan handles clean atmospheric air and has longer life compared to the exhaust fan
- In case of skip winding forcing fan is best

Laws of mine air friction

- When air passes in a mine it has to overcome the friction to the walls of the shafts/inclines and also of the floor, roof and sides of the roadways, the props, bars and other objects in its passage

$$P = \frac{KSV^2}{A} \text{ or } P = \frac{KSQ^2}{A^3}$$

- Where

- P = pressure absorbed in kgf/m²
- K = coefficient of friction, in kilomurg
- S = rubbing surface in m²
- V = velocity of air in m/sec
- A = area of cross section of roadway in m²
- Q = quantity of air flowing in m³/sec

- Coefficient of friction, kilomurg ($k\mu$) is the resistance of friction of an airway that absorbs a pressure of 1kgf/m² (1mm Water gauge), when 1m³ of air flows through it per sec
- 1 kilomurg = 1000 murg
- The unit of resistance in SI units is Ns^2m^{-8}
- 1 murg = $0.00981 \text{ Ns}^2\text{m}^{-8}$
- Smooth lined roadway – $0.00216 \text{ Ns}^2\text{m}^{-8}$

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- 1 murg = $0.00981 \text{ Ns}^2 \text{m}^{-8}$
- Smooth lined roadway – $0.00216 \text{ Ns}^2 \text{m}^{-8}$
- Unlined roadway in sedimentary rock or coal – $0.01118 \text{ Ns}^2 \text{m}^{-8}$
- Shaft, bricklined – $0.00618 \text{ Ns}^2 \text{m}^{-8}$
- Staple pit without bunton – $0.02256 \text{ Ns}^2 \text{m}^{-8}$

- The relation between pressure, resistance and quantity

- $P = RQ^2$

- Where

- P = pressure in kgf/m^2 or water gauge in mm
- Q = quantity of air flowing in m^3/s
- R = resistance of the airway in kilomurg

→ What is the water gauge required to pass 1500 m^3 of air /min, through an air way of $2.5 \text{ m} \times 3 \text{ m}$ Cross section & 200 m long?

Sol.ⁿ ⇒ Coefficient of friction ⇒ 0.001 KU

$$P = \frac{K S V^2}{A} \Rightarrow \frac{K S Q^2}{A^3}$$

$$A = 2.5 \times 3 \Rightarrow 7.5 \text{ m}^2$$

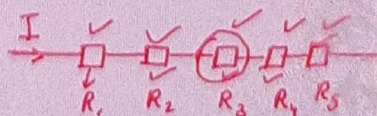
$$S = 2 \times (2.5 + 3) \times 2000 \Rightarrow 11 \times 2000 = 22000 \text{ m}$$

$$Q = \frac{1500}{60} = 25 \text{ m}^3/\text{sec.}$$

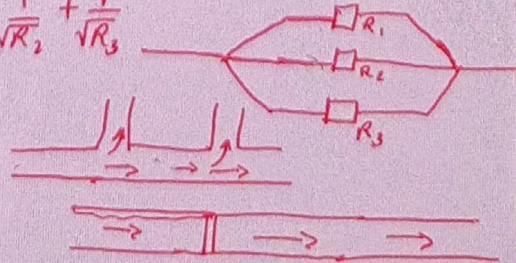
$$P = \frac{0.001 \times 22000 \times 25^2}{(7.5)^3} = 32.6 \text{ mm w.g.} = 326 \text{ Pascal}$$

Resistance of roadways

Series ⇒ $R = R_1 + R_2 + R_3 \dots$



Parallel ⇒ $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$



Sol.ⁿ $\Rightarrow$ Coefficient of friction $\Rightarrow 0.001 \text{ KU}$

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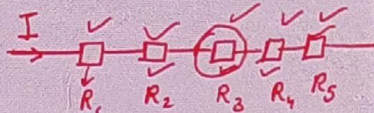
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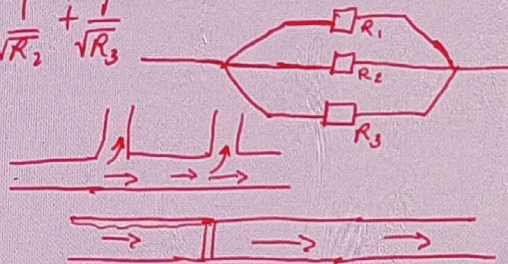
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Series $\Rightarrow R = R_1 + R_2 + R_3 \dots$



Parallel $\Rightarrow \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$



Laws relating to quantity, w.g. & fan speed

Q = Quantity of air (m^3/sec)

N = rpm of fan

V = Speed blade tips in m/sec .

Law No. 1 $\Rightarrow Q \propto N$ or V

Law $\Rightarrow \text{w.g.} \propto N^2$ or Q^2 or V^2

Law No. 3 - $\text{HP} \propto N^3$ or V^3 or Q^3

↓
Horse power re. - o rive - e fan.

2 $\rightarrow$ if the quantity of air has to be increased from $1500 \text{ m}^3/\text{min}$ to $3000 \text{ m}^3/\text{min}$ what will be the effect on HP of fan.

Sol.ⁿ $\frac{H_2}{H_1} = \frac{(3000)^3}{(1500)^3} = 2^3 = 8$

$$\frac{H_2}{H_1} = 8$$

H_2 is 8 times of H_1

$$H_2 = 8 H_1$$



MINING GYAN

Fan terminologies

By – Devendra Singh Tomar

Theoretical depression

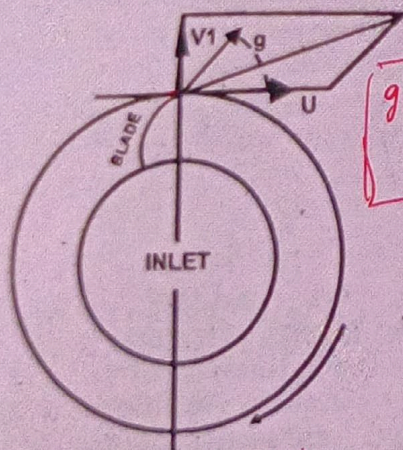
- It is the pressure difference that would be produced by mechanically perfect fan running under ideal conditions and connected to an evasee chimney of infinite height
- It value depends on speed of fan blade and the shape of fan blades and it varies as the square of speed

$$H = \frac{U(U \pm V_1 \cot \theta)}{g}$$

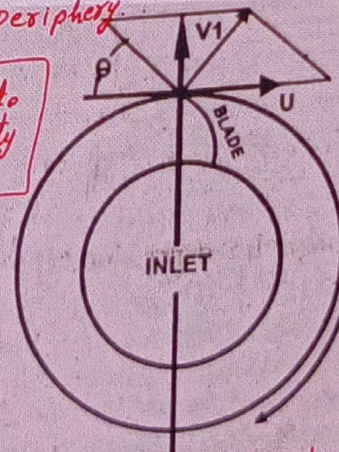
Where

H = Theoretical depression in m/sec of air column
 U = Peripheral speed of the blade tips in m/sec
 V_1 = Radial Velocity of air leaving the fan.

θ = External angle b/w the fan blade & tangent at the periphery.



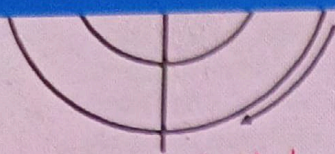
Forward Blade



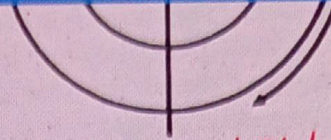
Backward Blade

The effective depression

- It is the pressure actually developed by the fan and expanded on overcoming the resistance of the mine
- It is measured by water gauge
- The effective depression varies with the quantity of air flowing i.e. it depends on the mine resistance on which fan is working



Forward Blade



Backward Blade

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- It is measured by water gauge
- The effective depression varies with the quantity of air flowing i.e. it depends on the mine resistance on which fan is working

The manometric efficiency

- It is the ratio between the effective water gauge and the theoretical water gauge produced by fan with the same dimensions and running at the same speed

$$\text{manometric efficiency} = \frac{\text{Effective w.g.}}{\text{Theoretical w.g.}}$$

HP of ventilation

- The useful power developed by an air current or the HP in the air is found

$$\text{Air HP} = \frac{P \times Q}{75} \text{ or } \frac{P \times Q}{\text{w.g.}} \text{ or } \frac{R \times Q^3}{75}$$

Where P = Ventilating Pressure: kgf/m^2

Q = Quantity in m^3/sec

R = Resistance in $\text{KM} \rightarrow \text{Ns}^2 \text{m}^{-8}$

- Power of ventilation or air power is the rate at which work is done to maintain the air flow through a system

$$AP = RQ^3 \times 10^{-3} \text{ KW}$$

Air Power in KW

Mechanical efficiency

- Power output by power input is termed as mechanical efficiency

$R = \text{Resistance in } \text{KM} \quad \text{N s m}$

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Mechanical efficiency

- Power output by power input is termed as mechanical efficiency
- If fan is direct driven BHP of the motor or engine may be accepted as the fan shaft HP
- If the fan is driven indirectly through gearing the efficiency of the drive must be estimated to arrive at the fan shaft HP

- A mine is ventilated by a fan producing 6000 cubic meter per min at 75 mm wg. The fan runs at 300 rpm and absorbs 160 BHP to increase the volume of air flowing through the mine the fan is speeded up to 400 rpm calculate volume of air at new fan speed and new water gauge, BHP and efficiency of fan

$$Q \propto N$$

$$\text{New Vol.}^m = 6000 \times \frac{400}{300} = 8000 \text{ m}^3/\text{min.}$$

$$\text{wg.} \propto N^2$$

$$\text{New wg} = 75 \times \left(\frac{400}{300}\right)^2 = 133.3 \text{ mm.}$$

$$\text{BHP} \propto N^3$$

$$\text{New BHP} = 160 \times \left(\frac{400}{300}\right)^3 = 379$$

$$\text{Air HP} = \frac{PQ}{75} = \frac{133.3 \times \frac{8000}{60}}{75} = 237$$

$$\text{Efficiency} = \frac{237}{379} \times 100 = 62.5\%$$

Equivalent orifice of a mine

- The equivalent orifice of a mine is the area of an imaginary opening in a thin plate which offers the same resistance to the

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Equivalent orifice of a mine

- The equivalent orifice of a mine is the area of an imaginary opening in a thin plate which offers the same resistance to the passage of air as is offered by the mine itself
- It is the area of opening through which would pass the same quantity of air as passes through the mine under the same pressure

Distribution of air

By - Devendra Singh Tomar



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Air Coursing → air की direction को change करना
or air को desired जगह तक भेजना

→ Brick stopping, doors, brattice cloth,
air crossing, air pipes / duct and regulators.

↓

Prevent leakage.

Ventilation stoppings → Reinforced → Thickness 15cm
Without Reinforcement → Thickness 25cm

↓

Thickness → 38cm.

→ Ventilation stopping → Incombustible material से बना होना चाहिए

↓

Plastered to prevent air leakage.

brick / stone.
lime / cement

→ **Air Crossing** → constructed where intake air & return air have to cross each other

↓

① Leakage Proof
② Fire proof.

Doors → used on roads which are required for haulage or travelling purposes

↓

Automatic closing arrangement / self closing

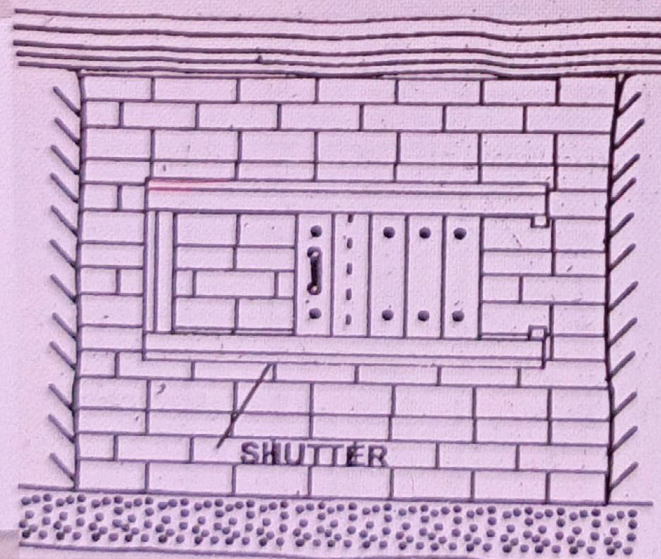
50-75mm

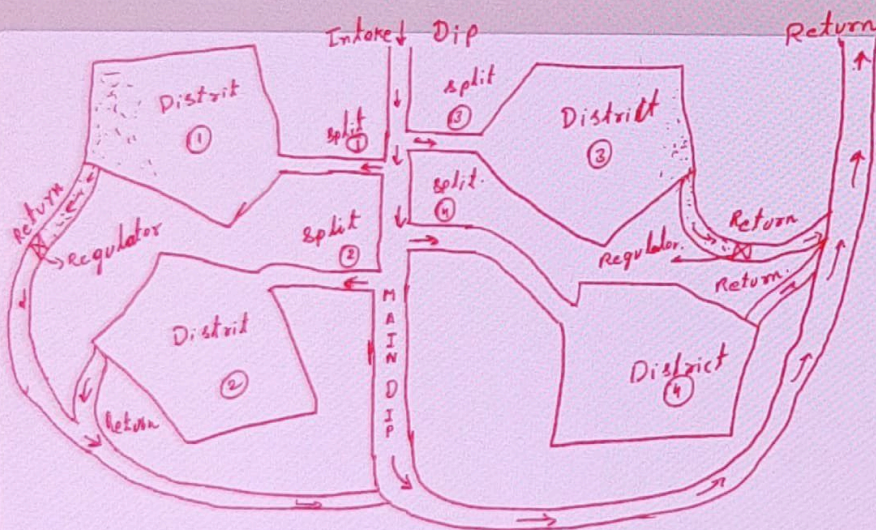
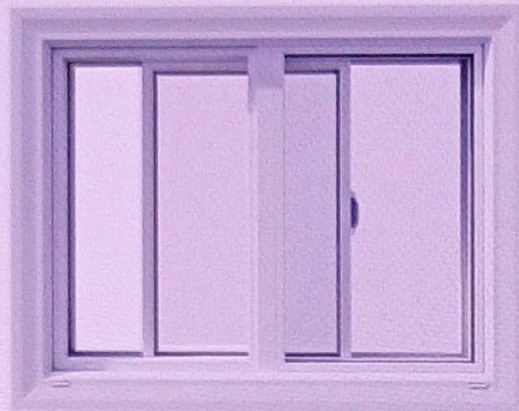
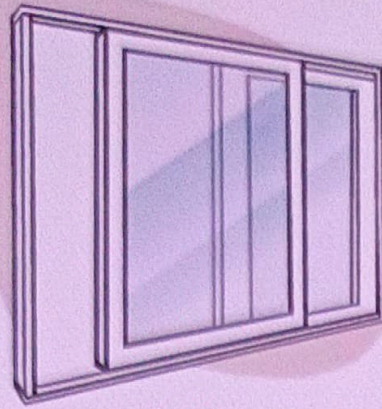
↓

To make it an inclination of 10° is given towards the direction of air flow.

- Regulator** → It is window of adjustable opening in a brick stoppings.
- It must have locking arrangement to prevent tampering by workers.
 - It increases the resistance of air current.
 - Used on the return side of district.
 - It should not be used on haulage roads.

- Regulator increases resistance of air current and जिस district में ventilation को reduce करना है उसके return में regulator लगा देते हैं
- +
Regulator को उसी जगह पर fix करना है जहाँ से पूरी district का air pass होता वाला है।
- Regulator reduces air flow in a split by increasing resistance of air current.
- +
increases in the other split





→ अगर जो district का return airway same है तो
regulator की intake side में लगाते हैं

+
Used for tubes or workers.

→ Regulator must be fitted in ventilation door.

Baffle Partitions → To course air up to face

Location → ① Inbye of last connecting gallery Main heading/Companion heading
② Windward Useful for a limited length

Used for tubs or workers.

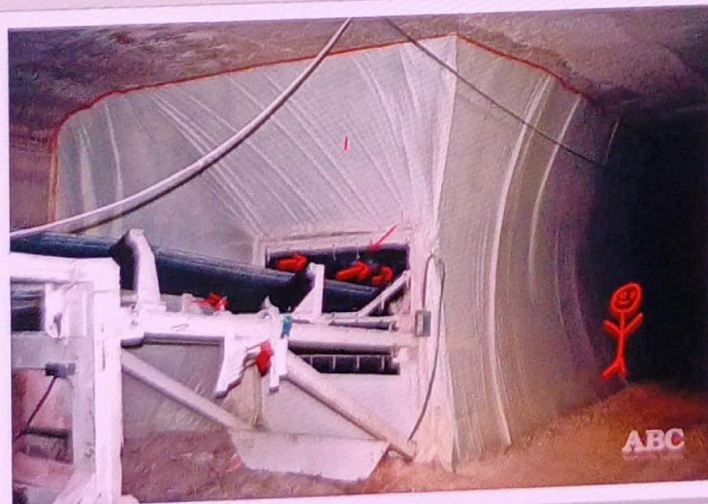
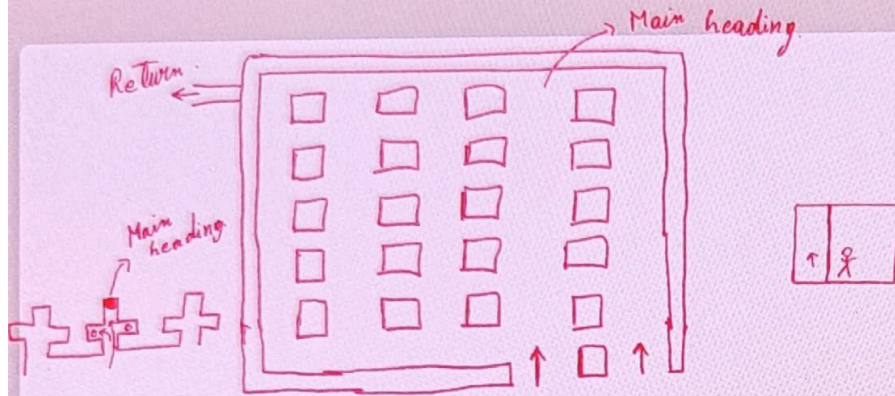
→ Regulators must be fitted in ventilation door.

Breathie Partitions → To course air up to face

↳ location → ① Inbye of last connecting gallery

② roadway useful for a limited length

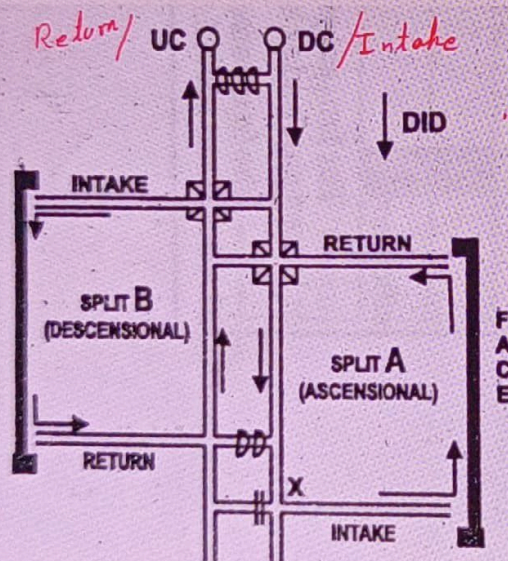
Main heading/Companion heading





Ascensional Ventilation → Intake air को district के lower point तक ले कर जाते हैं और
 Intake → Dip side/Lowest point
 Return → Rise side/Highest point return में जाना के पहले air को district के higher levels तक ले जाते हैं।

Descensional Ventilation → Intake air को district के rise side से lower level तक ले जाते हैं।
 Intake → Rise side/Highest point
 Return → Dip side/Lowest point



Preference of Ascensional Ventilation.

- ① Fire damp/hot air हल्का होने के कारण easily higher levels में travel करता है।
- ② अगर fan बंद हो जाता है तो Natural ventilation के कारण air continuously flow होगा।

Preference of Descensional Ventilation

→ In deep mines, dip side के water से pass नहीं करना पड़ता है and working face तक dry & cool condition में पहुँचना है।

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Homotropical Ventilation

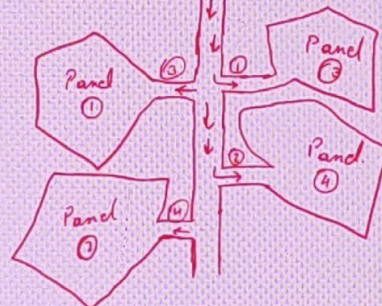
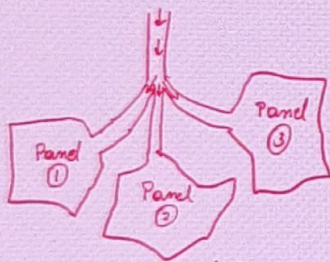
- Mineral & air flow in same direction
- Velocity of air relative to coal is less causing less coal dust at face.

Antitropical Ventilation

- Mineral & air flow in opposite direction
- Velocity of air relative to coal is more causing more coal dust at face.

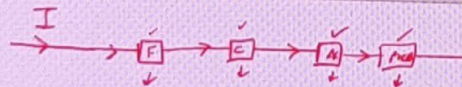
Splitting → Branch of air current from the main current
→ प्रत्येक district अलग अलग split अलग अलग ventilate करे

Parallel Connection

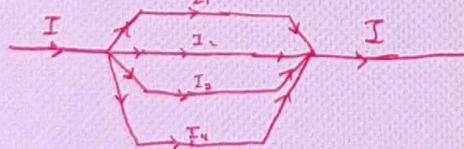


→ In parallel splits resistance of splits is less than the resistance of main Intake airway Series connection

Series ⇒



Parallel ⇒



Resistance

$$R_s = R_1 + R_2 + R_3 \dots$$

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$

Advantages of Splitting

- ① Provides fresh air to each ventilating district
- ② Reduces overall resistance of mine

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$

Advantages of Splitting

- ① Provides fresh air to each ventilating district
- ② Reduces overall resistance of mine
- ③ Large quantity of air supplies to mine
- ④ Reduces air velocity at roadways & face and coal dust formation also reduced.
- ⑤ Reduced air velocity has reduced drying effect on coal dust

Disadvantages of Splitting.

- ① Reduces no. of doors but increases the number of air crossings
- ② Large no. of splits result in less quantity in each district and reduced velocity
- ③ Reduced velocity will not be able to clear off gas

Leakage of Air.

- Sources $\Rightarrow$
- ① Doors of the fan drift & air lock.
 - ② where air lock is not provided, cages & shaft walls to air at space & and cages & pit top landing to air at space & at the source of leakage stop
 - ③ Ventilation stoppings, ventilation doors & air crossing
 - ④ In longwall mines $\rightarrow$ Packwalls.
 - ⑤ Broken or crushed pillars of coal.
 - ⑥ Wrong biting of VGR booster fan.

MINING GYAN

Air Leakage Prevention

- Proper design of air locks at pit top
- Doors of air lock & fan drift
 - ↳ ① Leakage Proof closing
 - ↳ ② Rubber lining
- Air lock के दोनो doors एक साथ नहीं खुलें होंगे नहीं
- Intake & Return → as far as possible
 - ↳ Very few connections.

- Ventilations doors, Ventilations stoppings and air crossing shall be well constructed.
- In Longwall method → Packwalls shall be well constructed.
- If pillars are broken/cracked → due to heavy roof pressure
 ↓
 should be coated by a spray of cement-mortar.
- Leakage Reduction → large no. of low pressure fan in series shall be used.
 ↳ not single fan producing high pressure

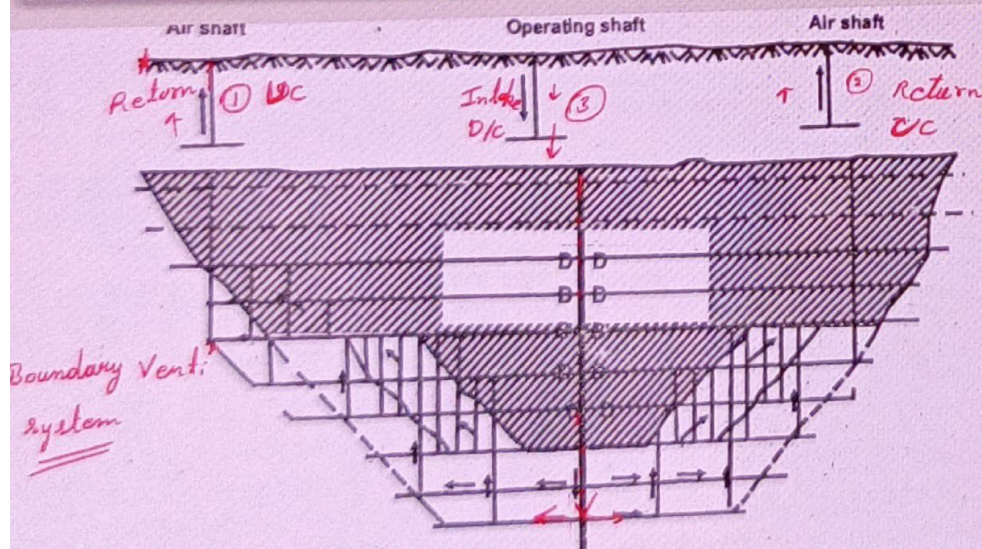


Fig. 3.5 [Boundary ventilation system] commonly adopted to metal mines.

Boundary Ventilation system

- UC & DC shaft are located at opposite ends of prop
- fresh & cool intake air goes to the lowest temperature is hottest.

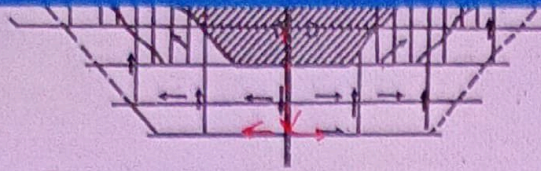
system

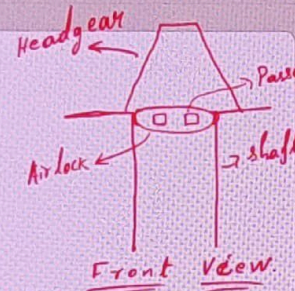
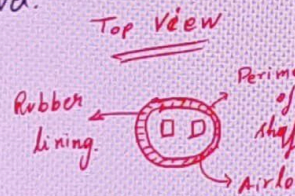
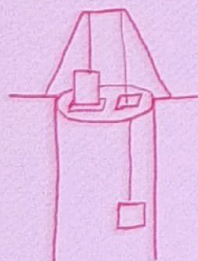
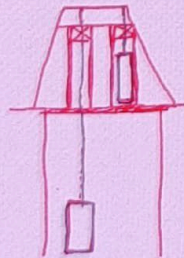
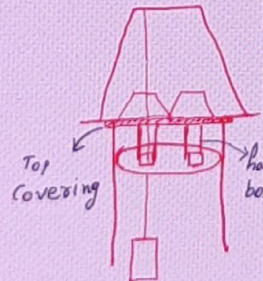
Fig. 3.5 [Boundary ventilation system] commonly adopted to metal mines.

Boundary Ventilation system

- VC & DC shaft are located at opposite ends of prop
- fresh & cool intake air goes to the lowest levels where rock temperature is hottest.
- Used in metal mines.

Air Locks.

- ① Standard type → at top of shaft.
- ② Guillotine type → Vertical steel Box fitted within headgear.
- ③ German type → below banking level.

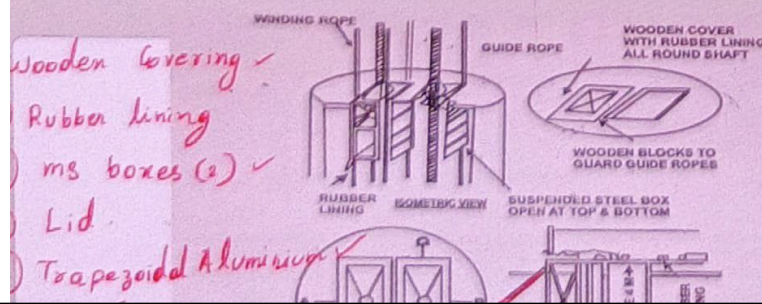
Front View.Top ViewStandard AirlockGuillotine AirlockGerman AirlockGerman Airlock.

- below banking level
- Pit top completely covered with steel joints and thick

German Airlock.

- below banking level
- Pit top completely covered with steel joints and thick wooden planks.
- 2 rectangular openings छोड़े हैं for passage of Cage.
- In these hollow openings on top & bottom 2 hollow boxes are suspended.
 - ↳ length = height of Cage.
- 2 hollow boxes of ms plates open at top & bottom openings of shaft & top covering से suspend किया जाता है।
- Pit top banking level को pit top covering के ऊपर लगाया जाता है।
- Pit top covering and shaft walls के बीच का space में rubber lining से close किया जाता है।
- hollow steel boxes suspended from the pit top covering are also lined with rubber sheets throughout the length.

- Aluminium की trapezoid shaped covering to cover suspension chain.
 - ↳ Small opening for the Passage of safety hook.
 - यह pit top covering के ऊपर रखा होता है।
 - ↳ small opening को cover करने के लिए wooden lid with a small hole for passage of rope लगा होता है।



Wooden Covering ✓

Rubber lining

ms boxes (2) ✓

Lid

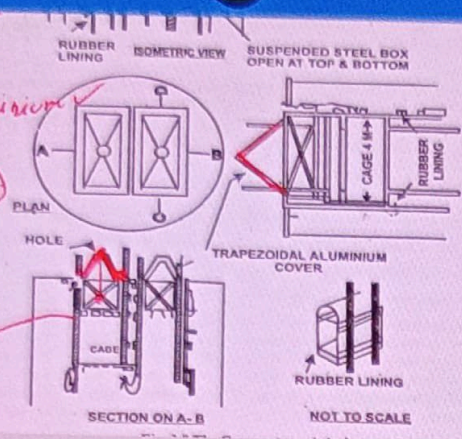
Trapezoidal Aluminium ✓

ms boxes (2)

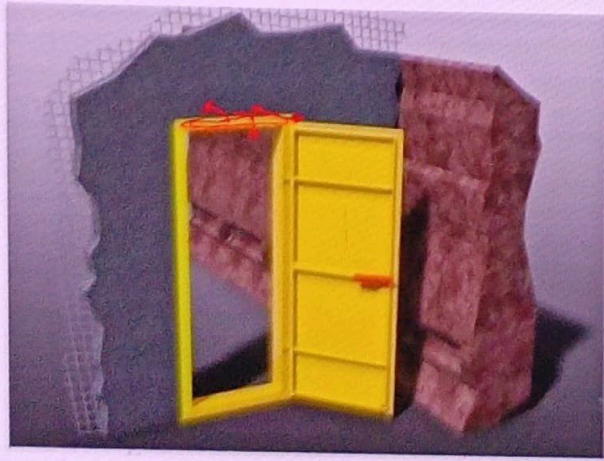
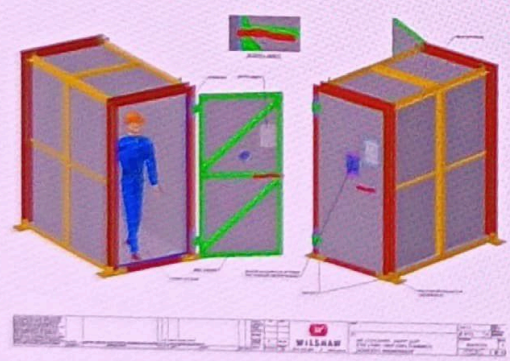
Lid

Trapezoidal Aluminium
COVER
(suspension chains)

Guide rope



Steel
hollow
Boxes.



Booster & Auxiliary fan

Installation of booster fan → To improve the quantity of air in one or more districts without increasing the total quantity of air circulated by main surface fan.

↓
It is a permanent Installation

Auxiliary fan → Temporary installation

↓
To Ventilate face of a district.

↓
district में circulate होत वहाँ air का रिस्क कुछ proportion में use करत है,

Uses of auxiliary fan

- ① long headings or stone drift.
- ② Clearing of roof fall which has obstructed normal air supply.

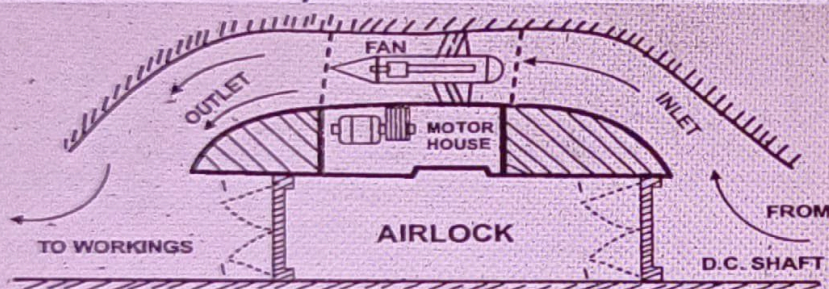


Fig. 3.9 Installation of booster fan : air screw fan.

Location of Auxiliary fan

1) Sufficient Quantity of air → not less than 2 times of the air drawn by the fan.

↓
To prevent re-circulation

2) No risk of contaminated air from being circulated

↓
Inflammable/ noxious gas Dust.

3) Within or less than 4.5m from entrance of district

↓
No auxiliary fan shall be installed

→ Auxiliary fan shall have air duct (leak proof)

↓
face/ blind end के within 3m तक air supply करने के लिए

→ 2 या इससे अधिक auxiliary fans same Ventilation district में install करने के लिए conditions CIM द्वारा specify किया जासकता है

supply करने के लिए

- 2 या उससे अधिक auxiliary fans same Ventilation district में install करने के लिए conditions CIM द्वारा specify किया जाएगा

Questions

- ① Within what distance of face/blind end auxiliary fan shall supply the air?

Ans ⇒ 3m

- ② Within what distance from entrance of district auxiliary fan shall not be installed?

Ans ⇒ 4.5m

- ③ Who will specify the cond.ⁿ for the installation of 2 or more Auxiliary fan in same district?

Ans ⇒ CIM

- ④ To which of the following locations auxiliary fan shall not be installed?

- ⑤ To which of the following locations auxiliary fan can be installed?

Capacity of auxiliary fan/withdrawal of air by auxiliary fan

→ Not more than 50% of total quantity of air flowing in the roadway.

Installation of 2 or more auxiliary fan in same Ventilation district or split.

- ① Type, Capacity & Location → On the basis of Scientific Study.

- ② Before & after installation

↳ VO के द्वारा atleast once every week at point of installation air की quantity measure किया जाना चाहिए

→ इस fan 2 impellers होते हैं जो की opposite direction में rotate करते हैं।

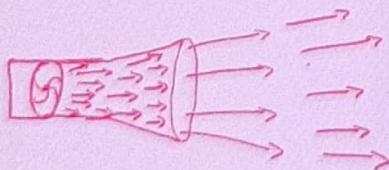
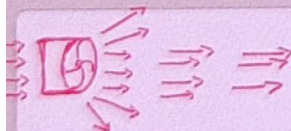
- (9) stoppage/re-starting को person द्वारा maintain किया जाएगा
- (10) Quantity of air delivered by auxiliary fan shall be regulated by Manager, VO and official
 ↓ dust में बाधा डालकर quantity को regulate नहीं किया जाएगा

→ Quantity of air to be circulated by an auxiliary fan
 (↳ Rate of gas emission पर depend करता है।
 ↳ $7 \text{ m}^3/\text{m}^2/\text{min}$ of working face

→ Device to control quantity of air
 ↳ ① Inlet Valve
 ② Damper Control.

Contra - Rotating Axial flow fan

- इस fan 2 impellers होते हैं जो की opposite direction में rotate करते हैं।
- Impellers cylindrical casing में होते हैं।
- इस इस impeller का खुद का motor होता है
- It helps in increasing power without increasing diameter.
- बिना guide vanes के use कर सकते हैं।



MINING GYAN

Air Tubes

- Working face तक air, sheet steel tubes or canvas tubing के through भेजा जाता है
- Air tight बनाने के लिए rubber के fabric का use करते हैं,
- ↳ Advantages → ① Light
② easy to handle
③ rolled up for transport.
- 8-16m के lengths में available होते हैं।

- shot-firing के पड़ने last few lengths की withdraw कर लिया जाता है।
- ↳ To avoid damage.
- Exhausting Ventⁿ के case में steel sheet air tubes का use करते हैं

Booster fan & Neutral line

- To increase air quantity in split or ventilating district of high resistance.
- fan install करने पर w.g. कुछ distance तक increase होता है।

Neutral line ⇒ Booster fan installation के बाद intake and return के किसी भी position पर pressure drop नहीं होता है तो उसी neutral line कहते हैं।

Effects of Booster fan

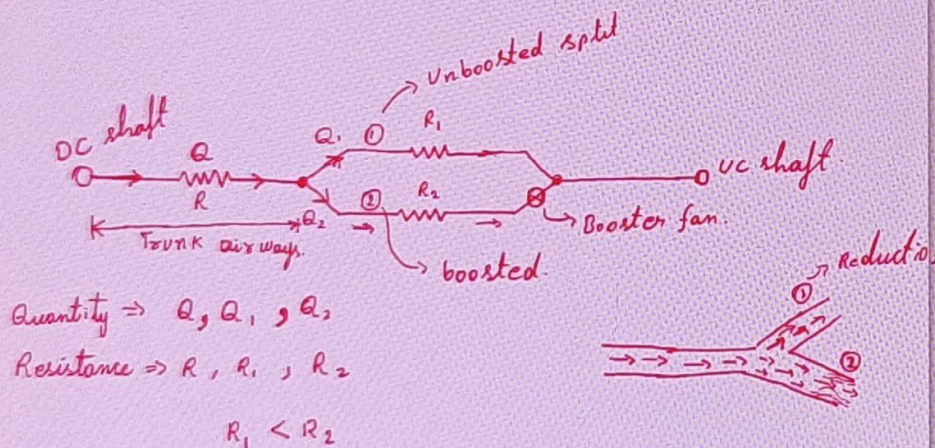
- ① Boosted district में air flow increase होने पर mines की total quantity of air increase होती है।
++ के कारण shaft & trunk

and return को करती है।
pressure drop नहीं होता है तो उस
neutral line कहते हैं।

Effects of Booster fan

- ① Boosted district में air flow increase होने पर mines की total quantity of air increase होती है।
- ② Quantity increase होने के कारण shaft & trunk airways में pressure का loss होगा and इसके कारण splits में pressure reduce होगा
- ③ Unboosted split में air की quantity reduce होगी

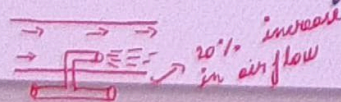
Critical pressure of booster fan → when the pressure difference at the point of splitting drops to zero.



→ अगर trunk airways का resistance high है और large booster fan किसी एक split में लगा दिया तो उसके कारण दूसरे split में air current का stoppage और reversal होता है।

Compressed air jets

- Compressed air अगर VG में available है तो air tube में Compressed air jet लगा दिया जाता है
- To increase the quantity of air in working face



30% increase in air flow

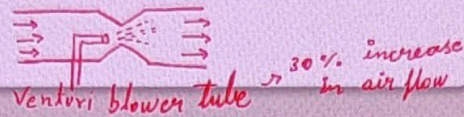
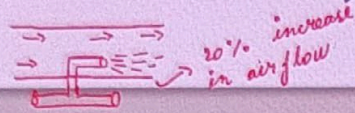
Removal of gas accumulation in a large cavity

- Overman & Assistant has to deal.
- CH_4 is 1.25% or more / FSL से measure कर सकते हैं

कारण दूसरे स्पष्ट न हो पाया
reversal होता है।

Compressed air jets

- Compressed air अगर VG में available है तो air tube में compressed air jet लगा दिया जाता है
- To increase the quantity of air in working face



Removal of gas accumulation in a large cavity

- Overman & Assistant has to deal.
- CH_4 is 1.25% or more / FSL से measure कर सकते हैं
- Suppose $\Rightarrow$ Cavity $\Rightarrow$ 15m long
 $\Rightarrow$ height 4m.
 $\downarrow$
 Intake & haulage road.

Steps to be taken

- ① Withdraw all workers
- ② Cut off electric supply
- ③ Ventilation tubing install करना है

$\swarrow$ 0.6m dia $\searrow$ galvanised iron sheets.

extending from cavity to nearest stopping by puncturing a hole in it.

- ④ firedamp की return की air suck करके अपनी तरफ खींच लेंगी
- ⑤ Inform the manager

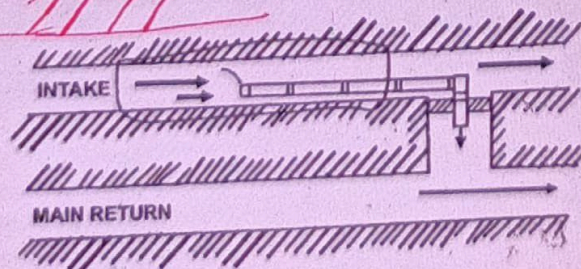
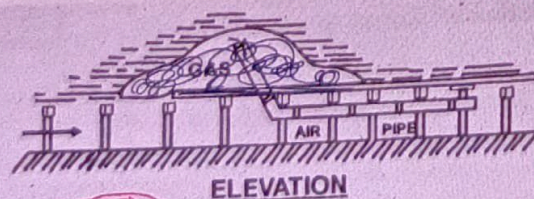
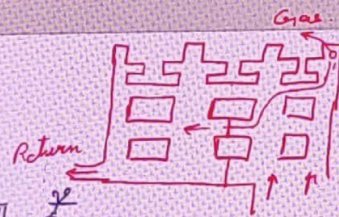


Fig. 3.14 Removal of gas accumulation in a large cavity

MINING GYAN

Ventilation Survey

→ Mines के Ventilation system को investigate करने के लिए किया जाता है।

- ① Adequate Ventilation system
- ② Points of leakage
- ③ Extent of leakage.

→ Investigation 3 तरीकों से किया जाता है।

① Quantity Surveying → Measurement of air velocity
→ Quantity of air flowing in various parts of mine

② Pressure Surveying

③ Qualitative Surveying → determination of fire damp at different strategic points.
→ Chemical analysis of air sample.

Quantity Surveying

① Distribution of air पता करने के लिए
→ in main roads.

② To locate leakages b/w intake and return

③ To know the efficiency of fan, during fan tests

→ Quantity measurement → at least once in a month

→ Quantity of air passing per minute.

$$Q = A \times V$$

where, Q = Quantity of air (m^3/min)

A = Cross sectional area of roadway (m^2)

V = average velocity of air in m/min at place.

→ Instruments used for measurement of air velocity

- ① Anemometer
- ② Velometer
- ③ Pitot tube

→ Mine entrance or working places में air की quantity upcast shaft के निकालने कम होती है because

① Warming of air

② all the dusts from machines/strata

place
→ Instruments used for measurement of air velocity
① Anemometer
② velometer
③ Pitot tube

→ Mine entrance or working places में air की quantity Upcast shaft के मुकाबले कम होती है because

- ① Warming of air
- ② Addition of gases from machines/strata
- ③ Expansion of air

→ Upcast shaft में air का expansion 1% per 100m depth में ले सकते हैं जिसके कारण air quantity भी increase होती है।

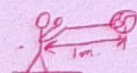
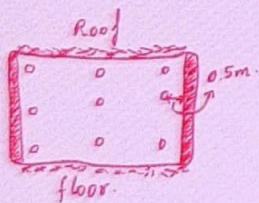
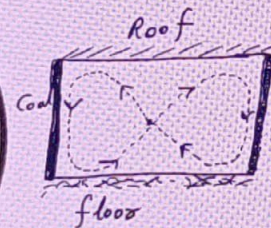
Anemometer → Given time में air कितना distance travel करती है। यह measure करने के लिए इस instrument का use करते हैं।

$$\text{Velocity} = \frac{\text{Distance}}{\text{time}}$$

Range → 60m/min to 1000m/min

→ यह एक small fan है जिसके vanes air flow के direction के 40° to 50° होता है

→ Anemometer के gears को clutch की help से operate कर सकते हैं

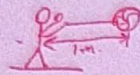
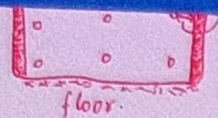


→ Instrument use करते समय body से दूर रखें

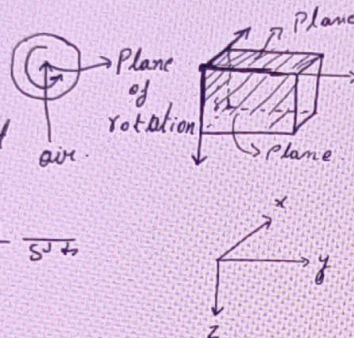
→ Plane of rotation of vanes → air के direction के normal होना चाहिए (90°)

→ Air Velocity measure करने के

- Plane



- Instrument use करते समय body से दूर रहें
- Plane of rotation of vanes → air के direction के normal होना चाहिए (90°)
- Air Velocity measure करने के लिए stopwatch का भी use करें।
- Stick का use करके instrument को body से दूर रहें
- Stop watch & anemometer को शुरू साथ start करें।



- 2 से 5 minute बाद de-clutch करके & stop watch बंद करके readings note down करें।
- Anemometer से हमें air ने किता distance travel किया इसकी readings देंगी

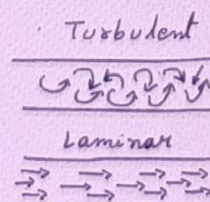
Locations for measurement of air Velocity

- ① Roadway का cross-section point of measurement को होना चाहिए 1.5m तक Uniform होना चाहिए
- ② Cross section ऐसा ही कि इसका area easily calculate किया जा सके
- ③ Away from → bends, junctions, place having sudden change in cross-section.

- free from obstructions which may cause turbulent air flow.

Electronic Anemometer

- Intrinsically safe
- Sensor head → non contact type
- Indicator Unit ⇒ measuring accuracy ⇒ $\pm 2\%$
- Measurement of air Velocity in 3 ranges.
 - ① 0.25 - 25 m/s
 - ② 0.25 - 5 m/s
 - ③ 0.25 - 10 m/s.



MINING GYAN

Velometer

- It directly indicates the air velocity in m/s
- UG mines में avg. air velocity पता करने के लिए equally spaced points पर spot readings ली जाती हैं।
- Micro circuits instruments को compact, trouble free and accuracy $\pm 2\%$ तक करता है।
- Instrument consists of sensing head and an indicator unit
- Head में rotating vane non-optical, non-magnetic and non contact type का होता है।
 - ↳ Remains unaffected by
 - Vibrations
 - dust
 - Temperature & humidity

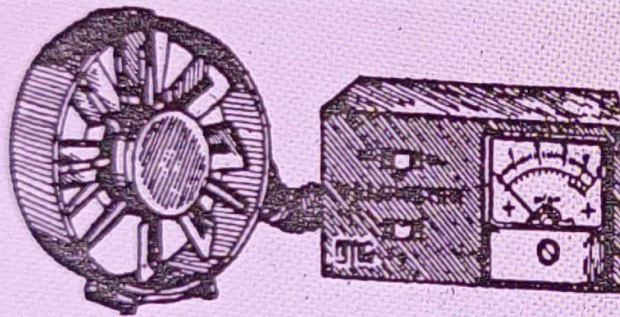
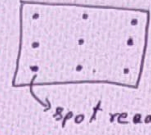
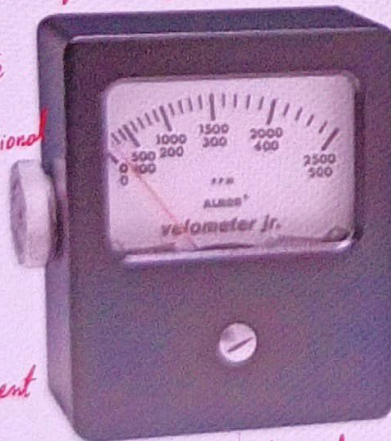


Fig. 3.16 Velometer, Directly reads air Velocity. Range 0 - 15 m/s (N.M.C.)

Transducer electrical signals generate करता है।

frequency rate
↓
directly proportional
to rate of
air flow



Rotating Vane
↓
Transducer
↓
electrical signal
↓
Direct current
Indicating meter

→ Signals direct current में convert हो कर indicating meter में air की velocity show करते हैं।

BA4 air Velocity Monitor

Detector head ⇒ Measures air velocity b/w 0 to 10 m/s.

↓
इसमें vortex shedding sensor use करते हैं

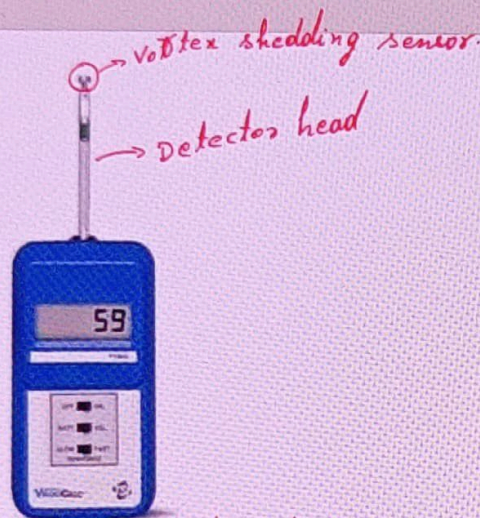
BA 4 air Velocity Monitor

Detector head $\Rightarrow$ Measures air velocity b/w 0 to 10 m/s.

इसके लिए Vortex shedding sensor use करते हैं जिसमें कोई भी moving parts नहीं होते हैं।

$\Rightarrow$ इसमें 3 ranges होते हैं $\rightarrow 0.2 \text{ m/s}$, 0.5 m/s , 0.10 m/s .

$\Rightarrow$ हर एक range को individually calibrate करते हैं, ताकि सबसे best range में air की velocity की measure कर सकें



BA 4 air Velocity meter

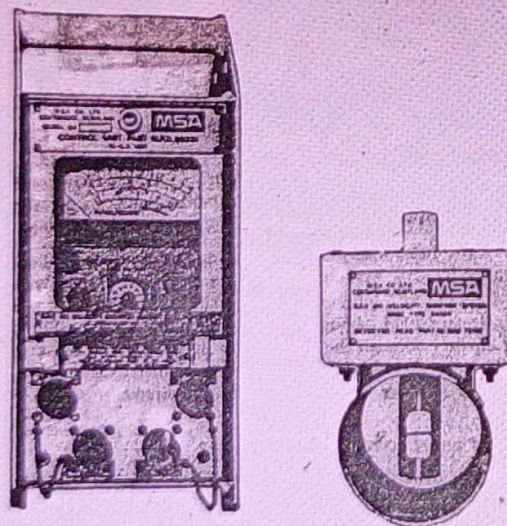


Fig. 3.17 BA-4 air velocity monitor. (Right) Detector head.

Control Unit $\Rightarrow$ इसमें एक indicator meter, alarm lamp and control करने के switches होते हैं

Controls

- ① Power Switch $\rightarrow$ ON, OFF, Battery check.
- ② Range switch $\rightarrow$ 3 ranges में से 1 range की select करने के लिए
- ③ Time Constant Switch $\rightarrow$ 3 Time Constants में से 1 time constant की select करने के लिए

- 1) Power Switch $\rightarrow$ ON, OFF, Battery check.
- 2) Range switch $\rightarrow$ 8 ranges में से 1 range की select करने के लिए
- 3) Time Constant Switch $\rightarrow$ 3 Time constants में से 1 time constant की select करने के लिए
 $\downarrow$
 15 sec, 30 sec, 60 sec.
- 4) Alarm set point $\rightarrow$ 0-100%

$\rightarrow$ Normal operation में alarm lamp 16 seconds में 5 बार flash करता है & alarm condition में 1 second में 5 बार

$\rightarrow$ Recorder Socket $\rightarrow$ To provide 0.4-0.2 Volt DC signals.

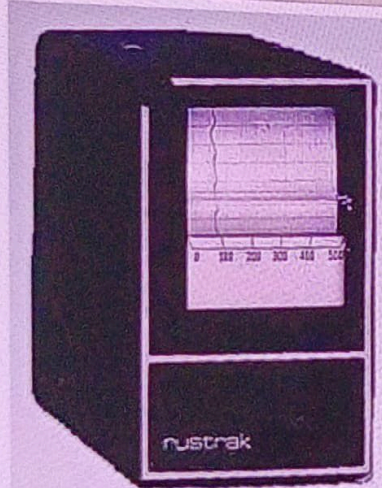
$\rightarrow$ Recorder Unit $\rightarrow$ Time marker

$\rightarrow$ Clock battery

$\rightarrow$ To indicate air Velocity

It contains Rusttrak recorder $\rightarrow$

chart speed 12.7 mm/hr.



Battery Pack $\Rightarrow$ 7 Ah $\rightarrow$ can be charged UG by flame proof power supply $\rightarrow$ 5 days

$\rightarrow$ 20 Ah $\rightarrow$ Surface charged only

$\rightarrow$ 12 days तक Power supply दे सकता है

7 Ah $\Rightarrow$ It is 20 hour rate $\rightarrow$ अगर battery लगातार

20 hours तक constantly discharge हो रहा है

तो वह 0.35 Amp/hour का current provide करेगा.

$$\frac{7}{20} \Rightarrow 0.35 \text{ amp/hr.}$$

MINING GYAN

Smoke Generator for Low Velocity

- Smoke and dust का use air की velocity measure करने के लिए किया जाता है।
- fuse को burn करके smoke generate कर सकते हैं
- 2 आदमी एक दूसरे से 100m की distance पर खड़े होते हैं।

↓
Stopwatch Smoke generator

→ Smoke को एक man से दूसरे man तक पहुँचने में जितना भी time लगता है उसे note करके air की Velocity calculate की जाती है।



- Smoke generator glass tube का बना होता है, glass tube में granulated pumice stone होता है जो की anhydrous tin / titanium tetrachloride से saturated होता है
- Smoke generator use करने के लिए glass tube के tip को break किया जाता है and aspirator bulb को squeeze करते हैं।
- tetrachloride के vapours का कारण white vapour का formation air में होता है।
- यह cloud dust के मुकाम पर air में लंबे समय तक exist करता है and air current के साथ flow करता है।

Precautions

- Smoke generator use करने के पहले upper & lower opening of glass tube को pin / hard wire से clean करना है।

→ यह cloud dust and air current से शांत flow करता है।
exist करता है।

Precautions

- Smoke generator use करने से पहले upper & lower opening of glass tube को pin / hard wire से clean करना है।
- Chemical Vapours के कारण opening बंद हो जाती है।

Application

- For determining low air velocity below the range of an ordinary anemometer i.e. below 1m/s.
- For testing air tightness of seals or stoppings.

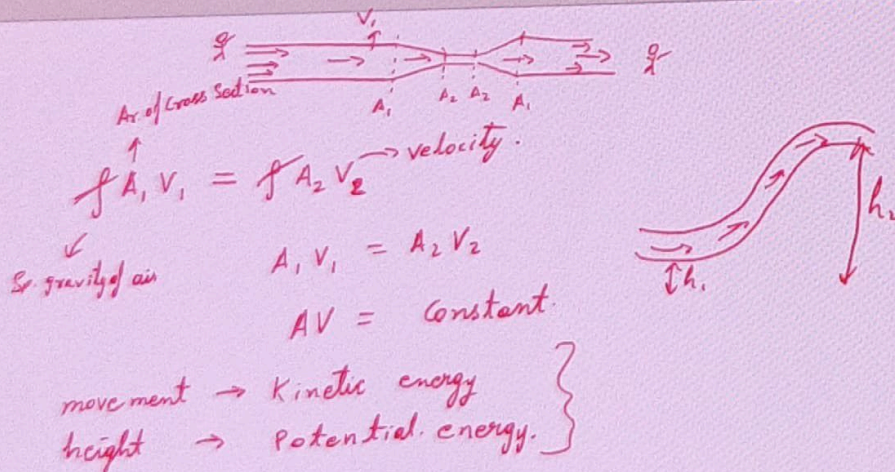
Pressure Surveying

→ Working principle → Bernoulli's Theorem.

→ Bernoulli's theorem ⇒ जब fluid एक ही cross-section से पास होता है तो कि the total energy of moving steam remains constant, assuming no friction loss.

⇒ Total energy ⇒ Kinetic energy + Potential energy.

⇒ Velocity energy $\propto \frac{1}{\text{Pressure energy}}$.



Pressure survey can be done in 2 ways.

- ① Aneroid barometer को अलग-अलग points पर total pressure measure करके pressure difference calculate कर लेंगे।
- ② By using a very sensitive inclined manometer.

$AV = \text{Constant}$

movement $\rightarrow$ Kinetic energy
height $\rightarrow$ Potential energy.

Pressure survey can be done in 2 ways.

① Aneroid barometer को अलग-अलग points पर total pressure measure करके pressure difference calculate कर लेते हैं।

② By using a very sensitive inclined manometer.

$\rightarrow$ First method में 2 sensitive, recently calibrated aneroid barometers को VG mines में use करने के काम में कम 24 hrs. पहले ले जाना है। ताकि वह VG pressure condition के हिसाब से adjust हो सकें।

$\rightarrow$ Second method में inclined manometer (containing alcohol) का use करते हैं।

accessories $\Rightarrow$ 2 flexible rubber hose pipes

each 100m long

$\Rightarrow$ Spirit level

$\Rightarrow$ Measuring tape

$\Rightarrow$ Ventilation plan

$\Rightarrow$ Tripod.

$\rightarrow$ Mark stations on Ventilation plan $\rightarrow$ where pressure drop has to be measured.

$\rightarrow$ Pressure survey shall be done on rest days

$\downarrow$

Ventilation appliances remain undisturbed

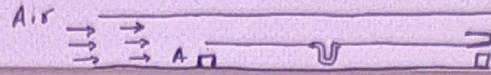
$\rightarrow$ fan speed should be constant

$\rightarrow$ Ventⁿ Condⁿ should be steady

Total pressure drop b/w 2 adjacent stations

$\rightarrow$ spread flexible hose pipe on both stations

- Connect inclined manometer in mine
- Keep hose ends facing the air current
- Manometer base shall rest on levelled tripod
- ⇒ No leakage at joints of hose pipes



Readings.

- | station length
(m) | Air Velocity
(m/s) | Quantity
(m ³ /sec) | Gauge
reading
(mm) | Velocity
correction | Corrected
pressure
drop
(mm of H ₂ O) |
|--------------------------------------|-----------------------|-----------------------------------|--------------------------|------------------------|---|
| → In shallow depth mines → Quarterly | | | | | |
| → In deep mines → Annually | | | | | |
| → CMR 2017 | | | | | |
| ① Deg. 1 → Once in 30 days | | | | | |
| ② Deg. 2 & 3 → once in 14 days | | | | | |

Ventilation problems in deep mines

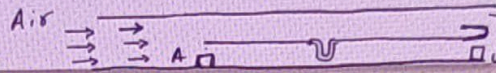
- The strata temperature gradually increases, raising the temperature of the mine air.
- Deep mines are dry, so the air current carries much underground dust.
- In coal mines, the deeper mines are known to be more gassy than the shallow ones; the quantity of gas liberated therefore increases and needs large quantity of fan air.
- The resistance to air current is high due to the large depth of the shafts and powerful fans developing large w.g. are required.
- Capital investment on shaft sinking, shaft winders, etc. is high.
- Interest on such heavy capital investment and depreciation forms a sizeable amount of cost per tonne and to keep the cost of production low, deep mines have to be planned for large outputs which require circulation of large air quantities.
- The main roadways have therefore to be of ample cross-section for the large volumes of air.

Measures

- Methane drainage in the case of coal mines
- Binding of dust instead of wetting it as wetting increases the humidity of air
- Sending conditioned air underground by reducing its temperature to nearly 0°C and eliminating its water content as far as practicable
- Use of descensional ventilation
- Arranging winding of coal/mineral in the return airway and in the upcast shaft
- Use of compressed air operated equipment instead of electrically operated machines.
- The compressed air is cooled and its moisture content considerably reduced by proper devices before sending it underground.
- The Compressed air mains are located in the D.C. shaft and intake airways and the water condensed in these compressed air mains is drained out automatically by suitable devices fitted on the mains at intervals.
- By covering the underground drains to minimise their water evaporation and entry into circulating air current.
- Use of portable air coolers or semi-portable spot coolers in hot stopes or development districts of metal mines.
- Installation of booster fan underground in air splits with high resistance.

→ Ventⁿ Condⁿ should be steady

- Total pressure drop b/w 2 adjacent stations
- spread flexible hose pipe on both stations
 - Connect inclined manometer at midway
 - ⇒ Keep hose ends facing the air current
 - Manometer base shall rest on levelled tripod
 - ⇒ No leakage at joints of hose pipes



Readings

- | Station length
(m) | Air Velocity
(m/s) | Quantity
(m ³ /sec) | Gauge
reading
(mm) | Velocity
Correction | Corrected
pressure
drop
(mm of air) |
|-----------------------|-----------------------|-----------------------------------|--------------------------|------------------------|--|
|-----------------------|-----------------------|-----------------------------------|--------------------------|------------------------|--|
- In shallow depth mines → Quarterly
 - In deep mines → Annually
 - CMR 2017
 - ① Deg. 1 → Once in 30 days
 - ② Deg. 2 & 3 → once in 14 days

Ventilation problems in deep mines

- The strata temperature gradually increases, raising the temperature of the mine air.
- Deep mines are dry, so the air current carries much underground dust.
- In coal mines, the deeper mines are known to be more gassy than the shallow ones; the quantity of gas liberated therefore increases and needs large quantity of fan air.
- The resistance to air current is high due to the large depth of the shafts and powerful fans developing large w.g. are required.
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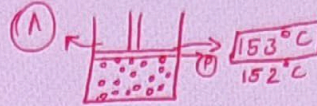
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MINING GYAN

Units of air conditioning plants

- The refrigerant circulation system
- The brine circulation system
- Coolant circulation system



Critical Temperature $\rightarrow$ वह temperature जिससे अधिक temperature होने gas को liquid में Convert नहीं कर सकते हैं।

Critical Pressure $\rightarrow$ अगर gas अपने critical temperature के भीतर है और gas जिस lowest pressure पर liquid में convert होता है।

Refrigerant circulation system

- Ammonia gas is compressed by a compressor and the gas at a high temperature and pressure
- It passes through an oil separator which extracts any oil picked up from the compressor cylinder
- Oil free gas passes outside the tube of condenser where it is cooled to atmospheric temperature by circulating water
- Due to this refrigerant gas liquifies
- Then it passes through float regulator – at needle valve gas expands and its temperature falls to -12°C
- Then goes to evaporator also called vapouriser

Refrigerant Circulation System

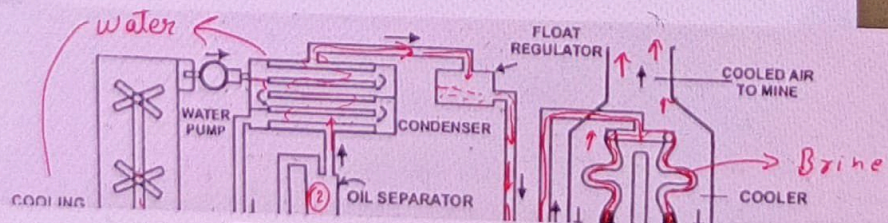
$\rightarrow$ Ammonia gas $\rightarrow$ Compressed करेगा

$\downarrow$ compress करते Hydraulic oil गलती में इसमें Leak हो जाया

$\rightarrow$ Oil separator $\rightarrow$ Ammonia में से oil separate करेगा

$\rightarrow$ Oil free gas $\rightarrow$ Condenser के pipes से बाहर निकलनेगी
 $\downarrow$
 Water की help से atmospheric temp. के बराबर इसके तापमान को कर देगा
 (cooled)

$\rightarrow$ float regulator
 $\downarrow$ gaseous portion expand करेगा $\rightarrow$ liquid का temp. घटेगा (-12°C)



Water की help से atmospheric temp.
 उसके तापमान को कर देगा
 (cooled)
 → float regulator
 ↳ gaseous portion expand करेगा → liquid का temp.
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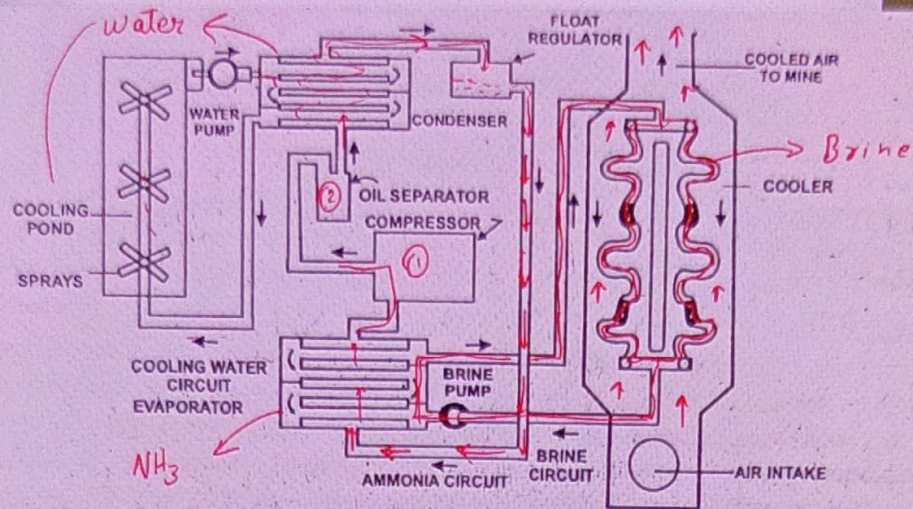


Fig. 3.21 Schematic diagram of the air conditioning plant at the surface of Giffords shaft at Kolar Gold Field (800 te cap).

Brine circulation system

- Brine is a weak solution of calcium chloride of sp. Gr. 1.22
- It is circulated by pump through a network of tubes in evaporator and then forced to DC shaft by forcing fan
- The chilled refrigerant absorbs heat from brine through evaporator and gets converted into gaseous state
- The cold brine cools the atmospheric air in DC shaft

Brine → Calcium chloride → weak sol.ⁿ
 ↳ sp. gravity → 1.22

Circulated by → Network of tubes in evaporator

chilled refrigerant → brine की heat को absorb करके brine को ठंडा कर देगा

→ Cold brine → Intake air को ठंडा करेगा

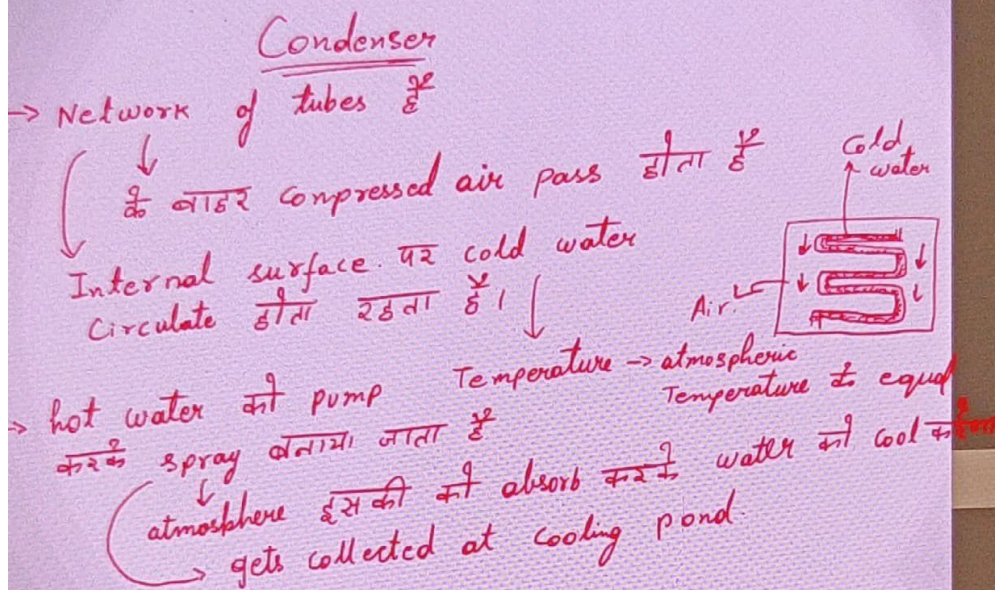
→ hot air को recirculation के लिए compressor में भेज दिया जाता है।

Condensor

- It is a network of tubes outside which the gaseous refrigerant passes and the internal surface of the tubes is in contact with

Condensor

- It is a network of tubes outside which the gaseous refrigerant passes and the internal surface of the tubes is in contact with the circulating water (called Coolant)
- The water absorbs heat from the refrigerant and the resultant hot water is pumped to form sprays which dissipates the heat to the atmosphere
- The cooling pond collects the water of the sprays for circulation



Refrigerants

- A good refrigerant should have large latent heat of evaporation and should evaporate and condense as near the atmospheric temperature and pressure as possible
- Refrigerant is ammonia in the industrial type refrigerant plants used on the surface
- Its critical temperature is 131°C and critical pressure 113atm
- The gas is cheap and has the largest heat of evaporation compared to other refrigerants
- It is toxic and corrosive for brass and copper
- Leakage of gas in a refrigeration system can be easily detected because of its smell and corrosion can be avoided by selection of suitable alloys for construction of the refrigeration system

→ Refrigerant → Ammonia gas.

↓

large latent heat of evaporation होने चाहिए

छुपी हुई heat

↓ किसी भी matter (वस्तु) की एक अवस्था (state) से दूसरी अवस्था में बदलना है।

Other refrigerants

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↓
large latent heat of evaporation हीना चाहिए
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→ किसी भी matter (वस्तु) की एक अवस्था (state) से दूसरी अवस्था में बदलता है।

States → Solid
→ Liquid
→ Gas

water → boil → 100°C
→ Vapour → 100.16°C → Gas
Liquid ←

- Other refrigerants – freon, carbon di oxide, methyl chloride
- For underground air cooling plant Freon – 12 is used as a refrigerant
- It is harmless, colourless gas and does not affect CI steels and other metals
- At atmospheric pressure its boiling point is 29.4°C
- It is 7 times costlier than ammonia
- Its leakage cannot be detected
- Joints should be tight
- Carbon di oxide can reduce compressor size due to its low specific volume but it is not suitable for mines because of its low critical temperature and toxicity
- In confined places of UG workings ammonia should not be used as it is toxic and forms explosive mixture with air, if present 30% by volume

Other Refrigerants → Freon, CO_2 , Methyl chloride

→ UG air cooling plants → Freon - 12

↓
 CF_2Cl_2 → dichloro-difluoro methane

harmless, colourless, does not affect CI

↓
Corrosion

→ Ammonia
→ Critical Temp → 131°C
→ Critical pressure → 113 atm
→ Cheap
→ Large heat of evaporation.
→ Toxic
→ Corrosive → brass & copper.

→ Ammonia gas leakage होने पर smell होता है जिसकी help से leakage को detect किया जा सकता है।

→ Freon → Ammonia की comparison में 7 गुना

जिसकी help से leakage को detect किया जा सकता है।

→ Freon → Ammonia के comparison में 7 गुना महंगा होता है।

↳ odourless → leakage can't be detected (गंधहीन)

→ CO₂ → Volume (अवयतन) कम होता है।

↳ Toxic
Critical temp → 32°C
Solid Carbon di-oxide → Dry Ice

- Brine is preferred with water when the air has to be cooled to low temperature because brine has a lower freezing point and hence is less likely to freeze in pipe lines.
- Calcium chloride and sodium chloride solutions are commonly used brines as they remain liquid under all temperatures
- The capacity of an air conditioning plant is expressed in tonnes
- A 1 tonne plant removes 3024kcal/hr heat from the air passing through it.

→ Brine → water के साथ इस्तेमाल करें

↳ freezing point water से कम होता है
freeze होने पर pipe lines freeze होजाइंगी
→ Calcium chloride / Sodium chloride
(CaCl₂) (NaCl)

सभी temperatures पर liquid form में पाए जाते हैं।

- ① specific heat is high
- ② stable

AC plant in Gifford shaft

- It is a 800tonne capacity plant and cools the intake air from 21°C to nearly 3°C
- It consists of reciprocating compressor, oil separator, condenser, evaporator, cooling pond with water sprays, water pump, brine pump, cooler
- The cooler consists of a large coil of 38mm bore steel pipes
- Ammonia gas is compressed by reciprocating compressor driven by a 300kW, 300 rpm motor
- the compressed gas, after passing through an oil separator, passes on to a condenser where it is cooled to liquifaction by circulating cold water by three 22kW pumps, each of 3m³/min capacity
- The cooling water extracts the heat of compression of the gas and also the latent heat of evaporation of ammonia
- The liquified ammonia passes to the evaporator through the float regulator which adjusts the flow that a constant level of liquid ammonia is maintained in evaporator
- The compressor compresses the gas during onward stroke and during return stroke a partial vacuum is created in the cylinder due to which liquid ammonia vaporises

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- After the extraction of heat from ammonia the cooling water gets warm and is cooled again in a spray pond

Gifford shaft (A/C Conditioning Plant)

- Capacity $\rightarrow 800\text{ te.} \rightarrow 1\text{ te} \rightarrow 3024\text{ Kcal/hr heat remove करता है}$
 - Intake air $\rightarrow 21^{\circ}\text{C}$ to 3°C
 - Plant consists of
 - Reciprocating compressor
 - Oil separator
 - Condenser
 - evaporator
 - Cooling pond & water sprays.
 - Water pump
 - Brine pump
 - Cooler.
- Pipe $\rightarrow$ steel
dia $\rightarrow 38\text{mm.}$

- In the evaporator a weak calcium chloride solution is circulated by 3 brine circulating pumps, each of $4.9\text{m}^3/\text{min}$ capacity
- The brine on leaving the evaporator, gets cooled and the cold brine is then circulated through the cooler
- A 2 stage axial flow fan, 2400mm dia, pushes the air to be cooled over the cooler pipes
- The brine after cooling the air, gets warm and has to be cooled again by the vaporisation of liquid ammonia in the evaporator

Surface AC plant

- Possibility of using a cheap refrigerant like ammonia gas resulting in cheapness of the plant
- Ease of disposal of waste heat
- Ease of getting water at surface temperature and facility of its circulation in unconfined space
- Convenience of operation, inspection and maintenance
- Surface plant produces large NVP because of large temperature difference of UC and DC air columns
- CO₂ or freon gas is generally used

Popularity Surface AC Plant.

- Ammonia use करने के कारण plant सस्ता पड़ता
- Waste heat को easily हटाया जा सकता
- Easily water is available at surface temperature
- Operation, Inspection & maintenance → easy.
- Produce large NVP → because of large temp. difference at UC & DC shaft.

Spot cooler

- Provided cool air to places which are uncomfortably hot
- Spot cooler is semi portable, small sized air conditioning plant with a fan installed UG with the limited purpose of supplying conditioned air to few working places
- Its cooling capacity varies from 37,800 to 126,000 kcal/hr
- Types of spot coolers
 - Where the direct evaporation of the refrigerant cools the air
 - Where an intermediate coolant such as water is used
- The compressors are usually of the reciprocating type and the cooling of the compressed refrigerant is done in air cooled condensers
- Spot coolers supply cool air at the working faces, they leave the rest of the mine hot

Spot Cooler

- Semi portable, small-sized Air Conditioning Plant
- Supplies conditioned to working places.
- Types → Directly cool करता refrigerant को evaporate करके
 - Intermediate coolant (water) का use करके cool करता है।
- Cooling Capacity → 37,800 to 126,000 Kcal/hr

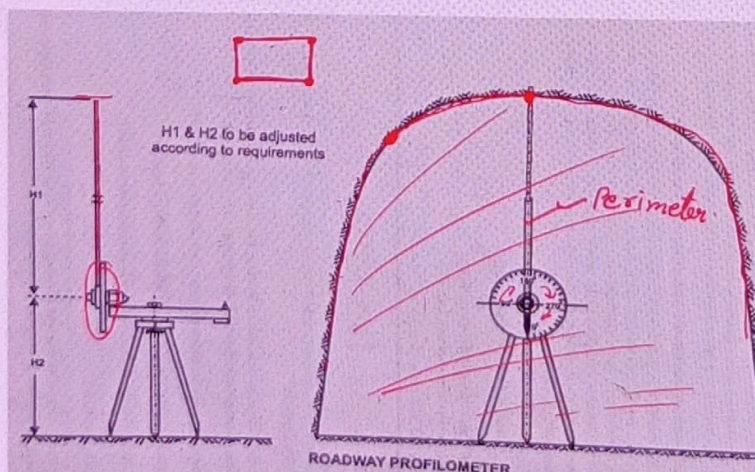
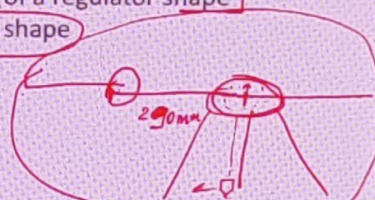
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Profilometer →

- In a mine the cross section of a roadway is rarely of a regular shape
- For measuring the area of a roadway of irregular shape
- It consists of
 - Tripod stand with adjustable legs
 - Quick clamping swivel head
- Plumb line is suspended for centering purpose
- Horizontal bar is screwed at the top
- A circular scale is graduated on one end of the bar 290mm away from the centre of the swivel head
- Its plane is at right angle to the axis of the horizontal bar
- A hub is mounted on bush bearing and it can be rotated and clamped in any position by clamping knob
- The hub carries a light radial arm of tubular aluminium, 9.3mm in dia and 1.06m in length
- Clamping screw can clamp the extension arm in any desired position



Area $\Rightarrow \frac{L}{3} (\text{sum of 1st \& last ordinates}) + 4 \times \text{times sum of even ordinates}$
 $L = \text{distance b/w 2 points}$ $+ 2 \times \text{times sum of odd ordinates}$

MINING GYAN

Conditions for ignition of fire

- Presence of a combustible material.
- Presence of a source of ignition of sufficient intensity of heat.
- Presence of oxygen
- Contact of combustible material and source of ignition for some time.
- For the fire to continue after it starts a sufficient supply of oxygen or air must be available.
- In the absence of oxygen the fire gradually dies down.

Conditions for Ignition of fire.

- 1) Combustible material
- 2) Source of Ignition → Intensity पर्याप्त होने पर चालू हो
- 3) Oxygen
- 4) Contact b/w Combustible material & source of ignition.
- 5) Fire की continuous supply of oxygen चाहिए to keep burning.



Combustible Material → burn

(→ Support Combustion
 (→ Release flammable vapours.
 → on a closed paper rubber & relative

Combustible Material $\rightarrow$ burn

$\rightarrow$ Support Combustion
 $\rightarrow$ Release flammable vapours.

eg $\rightarrow$ Wood, paper, rubber & plastics

Ignition Temperature $\rightarrow$ वह min^m तापमान जिस पर Combustible material जलना start करे है।

Lag on Ignition $\rightarrow$ Combustible material का heat source के contact में आने से लेकर आग लगने तक का समय (time period)



Classification of fires

- **Class A fires** - These fires involve combustible materials e.g. timber, coal, rubber, conveyor belt, other carbonaceous material
- **Class B fires** - These fires involve inflammable liquids eg. lubrication oils, diesel, petrol and other fuel oils, greases, etc.
- **Class C fires** - These fires involve gaseous fuels like LPG gas, butane, etc.
- **Class D fires** - These are metal fires such as melting iron, etc.



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- **Class D fires** - These are metal fires such as melting iron, etc.
- **Class E fires** - These fires involve live electrical equipments such as electric motors, generators, cables, oil-filled transformers, circuit breakers, electronic equipments etc.

CLASSES OF FIRE

Class A Fires



wood



cloth



paper

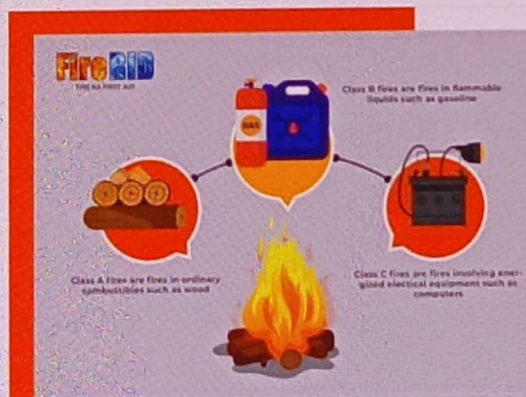


rubber



plastics

Fires that involves ordinary combustible materials such as wood, cloth, paper, rubber, and many plastics.

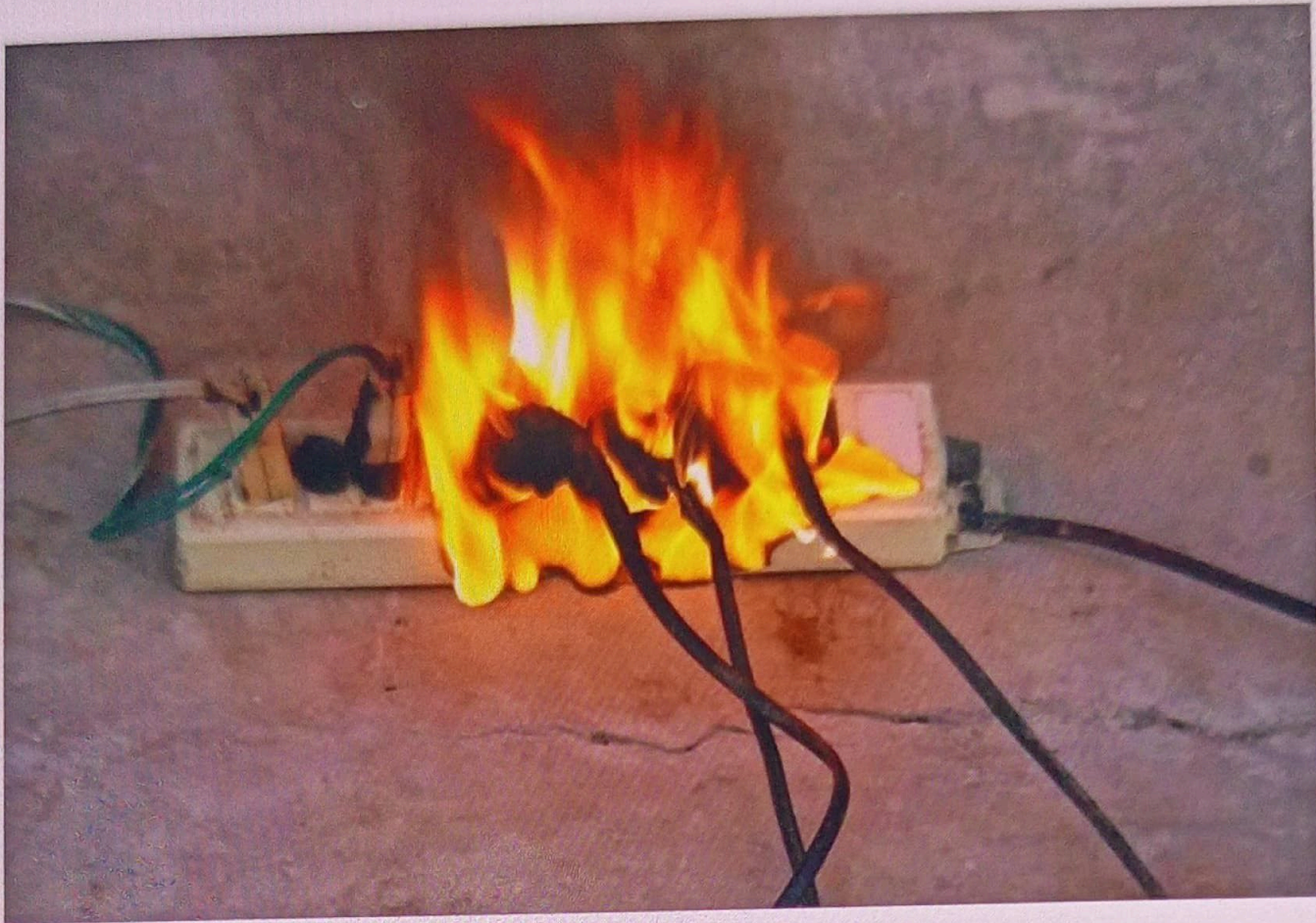


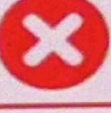
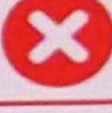
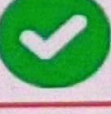
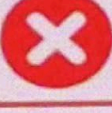
NFPA 10 Protection

Burning can be classified into one or more of the following fire classes and your fire protection specialist will select the right fire extinguisher size and agent for the hazard

www.fireaid.in





	Class A Flammable Materials (eg: paper & wood)	Class B Flammable Liquids (eg: paint & petrol)	Class C Flammable Gases (eg: butane & methane)	Class D Flammable Metals (eg: lithium & potassium)	Class E Electrical Equipment (eg: computers & generators)	Class F Cooking Fats and Oils (eg: fryers & chip pans)
 Water						
 Dry Chemical Powder ABE						
 Dry Chemical Powder BE						
 Carbon Dioxide CO2						
 Foam						
 Wet Chemical						

© fireextinguisheronline.com.au

Classification of Fires

 Foam						
 Wet Chemical						

Classification of fires

- Class A fires → timber, coal, rubber, conveyor belt.
 ↳ Combustible material.
 ↳ Carbonaceous materials
- Class B fires → Inflammable liquids
 ↳ Diesel, Petrol, Lubrication oil, grease
- Class C fires → gaseous fuels
 ↳ LPG, butane, CNG, CH₄.
- Class D fires → Metal fires
 ↳ Melting iron, Lava
- Class E fires → Live electrical equipments

Fire extinguishers for class of fires

- Class 'A' fires are generally quenched by water. Stone dust and sand may be used if the fire is on a small scale and in its early stage. Overhead fires cannot however be tackled by stone dust and sand.
- Class 'B' fires are quenched by an extinguishing agent which has a blanketing or smothering action and foam extinguishers are best suited for this purpose. Water, if used for extinguishing, spreads the oil and the fire along with it.
- Class E fires require use of extinguishing agent which is not a conductor of electricity. Water, with its normal impurities is a conductor of electricity and should not be used.
- A foam extinguisher is also not recommended but sand is suitable for smothering such fires in the initial stages on a small scale and the best extinguisher is the carbon gas.
- One of the advantages of CO₂ extinguisher is that it has no adverse effect on the insulation or other working parts of the equipment.

Fire Extinguishers for Class of fires

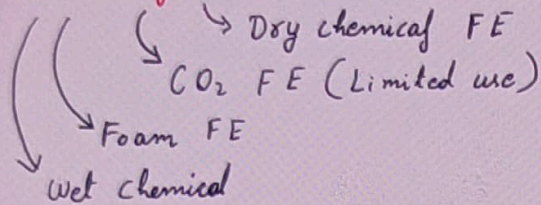
- Class A fire ⇒ water, stone dust, sand.
 / / ↳ Dry chemical FE

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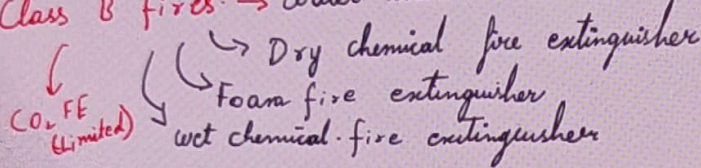
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Fire Extinguishers for Class of fires.

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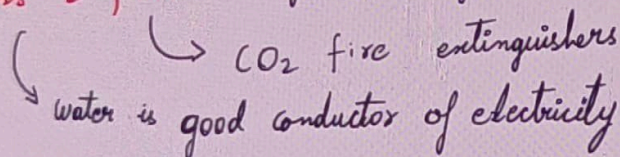
→ Class B fires → water should not be used.



Class C fires → None of the fire extinguishers can be used

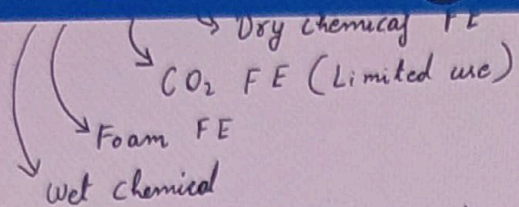
& Class D fires → CO₂ type, Dry powder.

Class E fires → Dry chemical fire extinguishers



Portable fire extinguishers

- At every entrance to a mine
- At every landing and shaft bottom in use



Class B fires → water should not be used.
 CO₂ FE (limited) → Dry chemical fire extinguisher
 Foam fire extinguisher
 Wet chemical fire extinguisher

Class C fires → None of the fire extinguishers can be used

Class D fires → CO₂ type, Dry powder.

Class E fires → Dry chemical fire extinguishers
 CO₂ fire extinguishers
 water is good conductor of electricity



Portable fire extinguishers

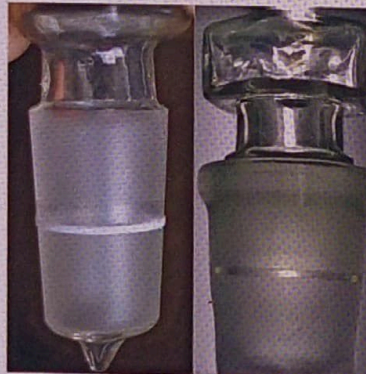
- At every entrance to a mine
- At every landing and shaft bottom in use
- At every engine room
- At every other place where timber, brattice cloth, grease, oil or other inflammable materials are stored
- At suitable places at the entrance to every district of a mine.

MINING GYAN

Types of portable fire extinguishers

- Soda acid
- Water CO₂
- Foam
- CO₂ gas
- Dry powder
- C. T. C – Carbon tetrachloride fire extinguisher
- B. C. F – Bromo chloride di fluoro methane fire extinguisher

Hermetic seal



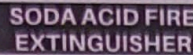
https://en.wikipedia.org/wiki/File:Glindemann_PTFE_Sealing_Ring_for_Taper_Joint_Glassware.JPG

Soda acid fire extinguisher

- It consists of a lead coated steel cylinder full of solution of soda bicarbonate and a hermetically sealed bottle of sulphuric acid placed inside a cage in the extinguisher.
- A spring loaded plunger outside the cylinder is so placed that when the plunger is struck against a hard surface it breaks the glass bottle of acid and the sulphuric acid reacts with sodium bicarbonate solution generating CO₂ gas.
- The gas under pressure forces the mixture of water and sodium bicarbonate up a tube and a nozzle to a distance of 6-8 m for initial 60 seconds in a 9 litre extinguisher and the total duration of discharge is 60 -120 sec.
- The CO₂ expels the soda bicarbonate solution partially dissolved in the water and helps in the quenching of fire when it is liberated as the water evaporates.
- Cooling action of water is the main factor in quenching the fire
- CO₂ helps it only partially.
- The jet of the solution should be aimed at the base of the flames.
- Such fire extinguisher is suitable for only class 'A' fires and is not recommended for class 'B' fires.



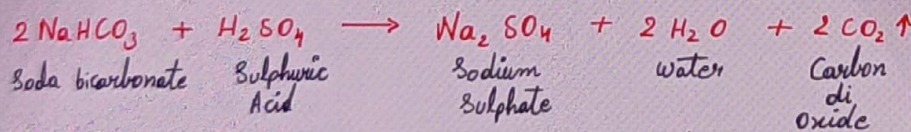
- Cooling action of water is the main factor in quenching the fire
- CO2 helps it only partially.
- The jet of the solution should be aimed at the base of the flames.
- Such fire extinguisher is suitable for only class 'A' fires and is not recommended for class 'B' fires.



→ It consists of → Lead coated steel cylinder
 ↓
 Soda bicarbonate solution से भरा होता है।
 Hermetically sealed bottle
 ↓
 Sulphuric acid

→ Spring loaded plunger लगा होता है cylinder के ऊपर
 Hard surface पर hit करने पर bottle break
 हो जाती है।

→ Sulphuric acid reacts with soda bicarbonate



→ CO_2 high pressure के साथ water & Soda bicarbonate को लेकर बाहर निकलता है।

(To a distance of 6-8m (for 60 sec.) in 9 litre

Total discharge duration $\rightarrow 120 \text{ sec}$.

→ water → cooling effect → आग बुझाने का काम

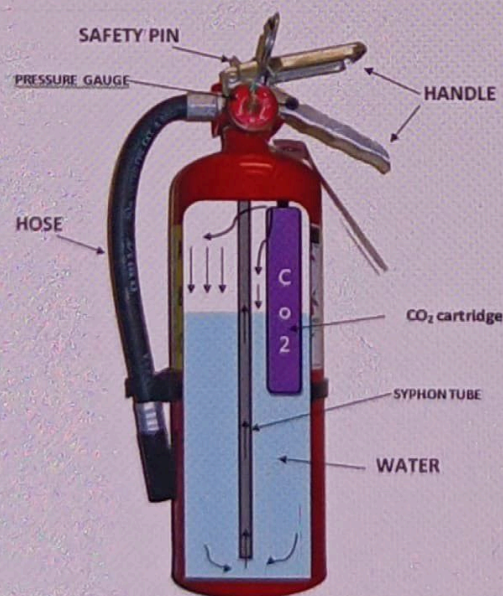
→ CO_2 → To cut oxygen supply

→ Suitable for → Class A fires.

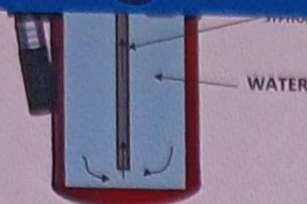
- It is prohibited by the mining regulations for quenching class 'E' fires.
- The extinguisher can be operated either in an inverted or upright position depending upon the model and instructions for operation are stated on the extinguisher itself.
- In general soda acid extinguishers of conical shape should be held in upright position and of cylindrical shape in inverted position during

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- The extinguisher can be operated either in an inverted or upright position depending upon the model and instructions for operation are stated on the extinguisher itself.
- In general soda acid extinguishers of conical shape should be held in upright position and of cylindrical shape in inverted position during use.
- The extinguisher can be refilled by the user at the site if refills are kept in stock.
- An extinguisher of 9-lit. capacity weighs 15 kg when full the soda acid extinguisher is also available as wheel mounted mobile model. One model of 45 lit.
- Capacity has 10 - 12m range of discharge for initial 100 sec. and total duration of discharge is 100-150 sec.
- During operation the mobile model has to be kept upright.
- The hose provided on it directs the jet in any direction.

- It consists of a steel cylinder coated inside with copper and containing water and a charge of high pressure CO₂ in a separate small sealed container of copper placed within the main cylinder.
- A spring loaded plunger protruding outside the main cylinder is provided at the top of this small CO₂ container. To operate, strike the plunger against a hard surface. This punctures the CO₂ container and the gas pressure forces the water out of the cylinder to nearly 12 m. It is effective for class 'A' fires only but not recommended for class 'B' fires and totally prohibited for class 'C' fires. The small copper cylinder containing CO₂ under pressure forms the refill and during use, specially in underground mines, the extinguisher can be recharged with water and the refill.



Water CO₂ extinguishers
→ It consists of → steel cylinder coated with copper
↓
small container of water

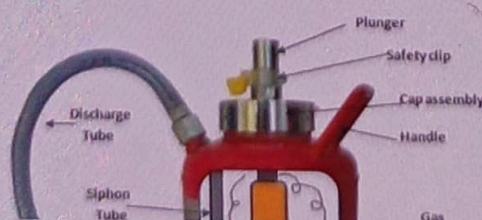
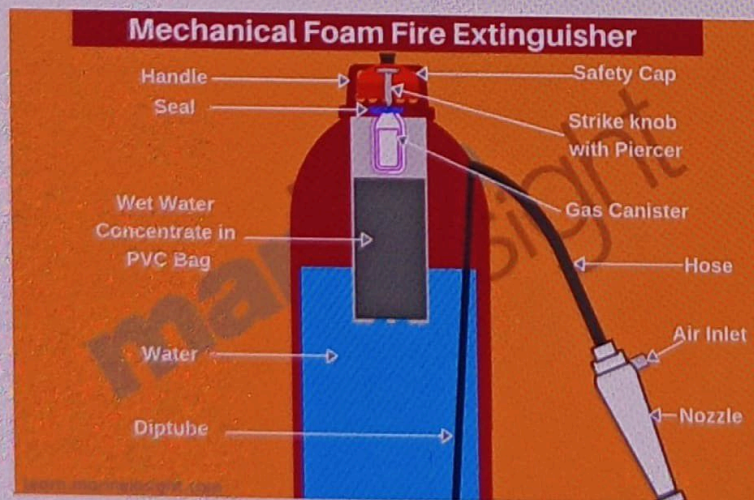


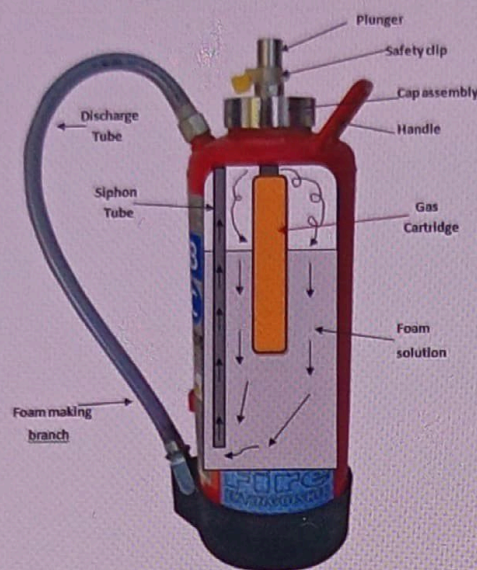
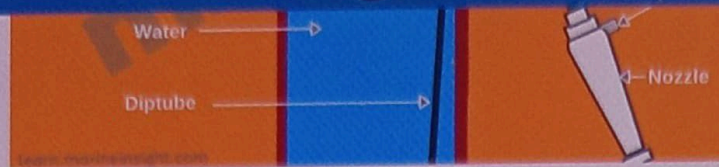
Water CO₂ extinguishers

- It consists of → steel cylinder coated with copper
 - ↳ water
 - ↳ Small container of copper
 - ↳ High Pressure CO₂
- Spring loaded plunger → CO₂ की bottle की break कर देता है on hitting
- CO₂ gas water की high pressure के साथ बाहर throw करता है → upto 12m.
- Used in Class A fires.
- Prohibited for Class 'C' fires.

Foam extinguishers

- In this extinguisher the foam produced during its operation forms a blanket on the flame and smothers the fire by stopping access of air. A foam type extinguisher is not permitted for dealing with class 'C' fires as the foam is a conductor of electricity but it is well suited for class 'A' and class 'B' fires.
- Types of foam type fire extinguishers
 - Chemical foam extinguishers
 - Air foam extinguishers





Foam Fire extinguishers.

- Operation के समय foam fire को cover कर देता है and oxygen supply cut कर देता
- Use → class A & B fires
- Cannot be used in class C fires.
- Types → chemical foam extinguishers
 - ↳ Air foam extinguishers

- It consists essentially of a vessel containing a solution of soda bicarbonate enclosing a scaled container of aluminium sulphate solution or similar foam forming solution along with a stabilising agent.
- During use the seal of the inside container (containing foam forming chemicals) can be released by turning a spring loaded plunger rod attached to it.
- When the seal is thus released and the extinguisher turned upside down chemicals of the two containers react to give CO₂ in the form of foam bubbles which are forced out of the nozzle under pressure.
- The foam has a smothering and wetting action with the flame, all foam type extinguishers have to be held upside down during use. The commonly used extinguisher of 9-litre capacity produces about 75 litres of dense foam.

Chemical foam extinguishers.

- ① Soda bicarbonate + Aluminium Sulphate
- ② जब plunger को hit करते हैं तो fire extinguishers को उल्टा करके उपयोग में लाया जाता है

Chemical foam extinguishers.

- ① Soda bicarbonate + Aluminium Sulphate
 - ② When plunger is hit it starts fire extinguishers and upside down it starts chemicals and they mix and start to form foam bubbles and then CO_2 gas formation starts.
 - ③ Refilling can be done by user.
- Air foam extinguisher → Soda bicarbonate & Aluminium Sulphate
In Powder form

- In "Firex" foam type extinguishers the foam refill basically consists of two packets of powder i.e. aluminium sulphate and sodium bicarbonate.
- Refilling can be done by the user at the site.
- The total duration of discharge of foam in a 9-litre extinguisher is 50 - 90 seconds with an effective range of discharge 6-8 m for initial 40 seconds.
- The wheel mounted mobile extinguishers are of 45 litre or 135/ 150 litre capacity.
- The 45-litre capacity extinguisher produces 360 litres of dense foam and has a duration of discharge as 75 - 120 seconds and effective range of discharge 11-14 m for initial 75 seconds.
- The 135/150-litre extinguisher has 90-135 seconds duration of discharge and the effective range is 11-17 m for initial 100 seconds.

CO₂ Extinguishers

- It consists of a cylinder having one to five kg of CO₂ in liquified form under high pressure (70 kg/cm²) which can be released during use by operation of a wheel valve mounted on its top as in the case of the familiar Indane gas cylinder used for domestic cooking.
- This is by far the simplest portable fire extinguisher and has the advantage that it can be used for fire of any class including electrical fires.
- No residue is left on the extinguished material.
- The gas penetrates to otherwise inaccessible places.
- CO₂ has the property of quenching the fire and the gas leaving the extinguisher is at a very low temperature so that it exerts a cooling effect on the burning material.
- All CO₂ gas type extinguishers are provided with funnel shaped discharge horns and the CO₂ leaves the extinguisher in the form of a dense but very cold white cloud.
- Such extinguisher can now be used where air current is not brisk.
- In a well ventilated underground roadway the CO₂ may be carried away by air current rendering the extinguisher ineffective.
- The refilling of CO₂ can be done only at the manufacturer's factory.
- During operation the extinguisher has to be held upright.
- One should not enter the premises affected by the immediately after use of the CO₂ gas extinguisher.

CO₂ Extinguishers.

- 5 kg के cylinder में liquified CO₂ under high pressure (70 kg/cm²) fill करके रखा जाता है।
- Rotating wheel की घुमा का pressure release करने पर CO₂ निकलेंगा।
- It can be used for any type of fires.

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- Rotating wheel की घुमा का pressure release करने पर CO₂ निकलता
- It can be used for any type of fires.
- Extinguished material के ऊपर कोई भी residue नहीं बचता है।
- Gas का use inaccessible places में भी कर सकते हैं।
- gas जब fire extinguishers से निकलते समय temperature low होने के कारण cooling effect.
- It forms a cold white cloud.
- Refilling → by the manufacturer.

Dry powder type extinguisher

- An extinguisher of this type can be used for dealing with fire of any type including electrical fire
- It contains a fire quenching powder and a container of high pressure CO₂ both placed inside a cylinder.
- The dry powder is a mixture of chemicals consisting of mono ammonium phosphate as the main ingredient and other chemicals which have anti-setting and water repellant properties
- The powder has very little cooling effect on the fire but it forms an adhering glassy crust of metamorphic acid over the combustible material and retards further combustion.
- The fire quenching powder goes by the trade name 'Firex-Nugas' in the Firex make fire extinguishers
- The powder is water repellant, non corrosive, non toxic, non conductor of electricity and will not deteriorate or cake when stored
- It is free flowing at all temperatures.
- The extinguisher can be recharged on the spot by the user with suitable refills

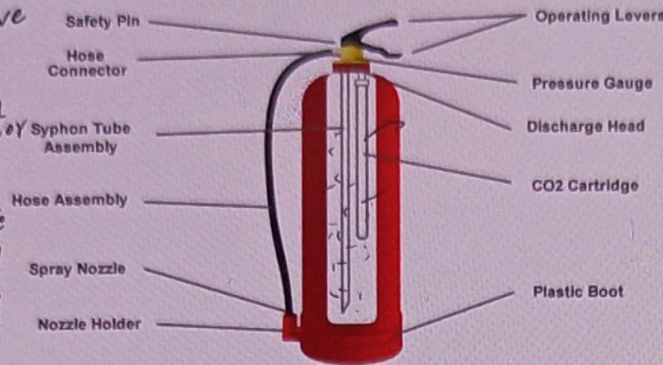
Properties of Powder

- ① water Repellant
- ② Non Corrosive
- ③ Non toxic



Properties of Powder

- ① Water Repellant
- ② Non Corrosive
- ③ Non Toxic
- ④ Non Conductor
- ⑤ Not deteriorate
- ⑥ If stored safely will not cake.



Dry Powder Extinguishers

- Can deal with any type of fire.
- Contains fire quenching (जुझान वार्ता) powder
- Contains high pressure CO₂.
- Dry Powder → mixture of mono ammonium phosphate & anti setting chemicals
- ↓
- Cooling effect is very less.
- ↓
- Refilling → by user
- ↓
- water resistant वार्ता

- The CO₂ gas cartridge is specially designed for withdrawal and inspection trolley
- Dry chemical fire extinguishers are available in capacities of to 12 kg of dry powder
- The mounted units are available in 25 and 70 kg capacity models.
- To put the extinguisher in operation, strike the knob or plunger rod against a hard surface.
- This releases the high pressure CO₂ into the chamber containing dry chemical powder which is shot out of the cylinder under the gas pressure.
- The powder is discharged in a fan shaped cloud and it settles on the surface of the burning material or liquid and stops access of oxygen to it.
- The "squeeze grip" valve at the end of a hose pipe enables the operator to control the discharge of the powder
- For quenching the fire the extinguisher has to be held erect and not upside down.

CTC Fire Extinguishers

- Carbon tetrachloride is a liquid at normal temperature but it evaporates easily
- Its cooling effect is high and when the liquid comes in contact with burning material the cooling effect quenches the fire.
- C. T. C. is a non-conductor of electricity and therefore the C. T. C. type extinguisher can be used for electrical fires in generators, sub-stations, transformer rooms, etc.
- When evaporated C.T.C. forms fumes which are toxic, hence the extinguisher should not be used in confined space and in underground

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- When evaporated C.T.C. forms fumes which are toxic, hence the extinguisher should not be used in confined space and in underground mines.
- The C.T.C. fire extinguishers are used on motor cars or automobiles as handy units in 2-litre capacity models.
- The liquid is discharged by gas kept under pressure inside the cylinder.
- These extinguishers are being gradually withdrawn from use.

CTC Fire Extinguisher

→ CTC → Carbon Tetra Chloride

↓
Room temperature at liquid state at 37°C
Evaporates very quickly

→ Cooling effect is very high

→ Uses → Electrical fire generators, sub-stations, Transformer rooms.

→ Evaporate at toxic fumes release ~~from~~ ^{from} it
→ should not be used in UG mines.

BCF Fire Extinguishers

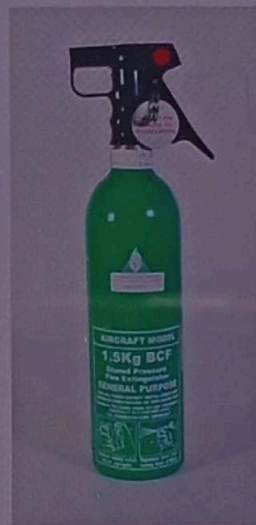
- A liquid called B. C. F. (bromo chloro di fluoro methane) is gaining popularity as a fire extinguishing medium in place of C. T. C.
- B. C. F. is a clear, colourless liquid at normal atmospheric temperature with the following properties.
- Formula: CBrClF_2
- Molecular weight: 165.4
- Boiling point: 80°C
- Freezing point: minus 4°C
- Odour: Similar to the halogen group of compounds Liquid
- Sp. gr. at 21°C : 1.83



→ should not be used in VCI machines

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BCF Fire Extinguisher

- BCF - Bromo chloro di fluoro methane
- It is a clear, colourless liquid at normal atmospheric temperature.

Effects of BCF on humans.

- ① Effect on human flesh → Not much effect (hazard)
 ↳ due to less boiling point liquid evaporates quickly → chilling sensation

② Effect on metals & non-metals

- ↳ Chemically stable होता है।
- ↳ CTC के कारण Corrosion effect कम होता है।
- ↳ but can be stored in common metals
- ↳ Nitrited Rubber use कर सकते हैं।

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Effect on metals & non-metals

↳ Chemically stable होता है।
 CTC के मुकाबले Corrosion effect कम होता है।
 but can be stored in common metals

Joints → Nitrited Rubber use कर सकते हैं
 ↳ Rubber (Normal) पर swelling effect show करता है

Electrical Conductivity → Electricity का कुचालक (insulator) है।

↳ Can be used to deal with Class E fires
 BCF is also known as Halon

Effects of BCF

- Effect on human flesh:** BCF does not present any hazard by absorption through the skin. Having a low boiling point the liquid evaporates quickly and gives a chilling sensation if spilled onto the skin out it cannot cause low temperature burns as CO₂ does.
- Effect on metals and non-metals:** BCF is chemically very stable and it does not show corrosion like CTC. In the absence of water BCF can be stored satisfactorily in containers made from most common metals. BCF causes natural rubber to swell but its effect on nitrited rubber is very small and these can be used satisfactorily for gaskets and joint rings.
- Electrical conductivity:** BCF is a non-conductor of electricity and can therefore be used to deal with class E fires. B.C.E is also known as Halon. Halon 1211 is used for extinguishing fires.

MINING GYAN

Fires in mines

- Store yards, engine/transformer houses, offices and places.
- Overburden dumps in coal mines
- Exposed coal in quarries
- Coal stacks
- Coal in bunkers of coal handling plants

Surface fires

- Fire in store yards, engine houses
- Electrical:- Short circuiting of electrical wiring, sparks from welding apparatus or electric motors and equipments
- Embers of coal or other fires:- Insufficient care or negligence causes spread of fire due to these reasons
- Carelessly thrown cigarette, biris at places containing kerosene oil, lubricating oil, grease, oil soaked cotton waste, paper and other combustible material
- Hot surfaces:- Hot surfaces of electrical motors, steam engines or internal combustion engines in contact with combustible material
- In the overburden dump these carbonaceous materials catch fire due to spontaneous heating
- Another reason for fires in OB dumps is the burning of coal over these dumps in winter nights by quarry workers to get warmth

Surface fires

→ Store yards, engine house etc.

① Electrical → short circuit of electric wiring.
 ↳ welding & spark generate हीन के कारण
 electric motors & equipments & spark generate
 हीन के कारण

② Embers of Coal → आग बुझने के बाद जो red
 colour का coal रह जाता है उसे
 embers of coal.

It should not
 be neglected.





- ③ Carelessly thrown → Cigarette
 ↳ biri ↳ at places
 ↓
 Kerosene, lubricating oil
 grease, oil soaked cotton
 waste or on any
 combustible material.
- ④ Hot surface
 ↓
 electric motors → steam engines
 on hot surface.
 ↓
 Internal combustion engines.
- ⑤ Spontaneous heating
- ⑥ Winter season में workers
 के द्वारा रात में आग
 लगाना to keep warm.

Preventive measures

- Stacking ground should be hard and firm, free from growth of any vegetation. A concrete surface is ideal
- Coal should be screened and a stack should contain coal of one size only. Fires easily take place in coal heaps where the coal of different sizes is stacked together
- Shale pieces in contact with coal are known to accelerate spontaneous heating
- The coal stack should not exceed 200 tonnes and its height should be between 1.5m and 3m
- The coal stacks should be cleared on the basis of first come first removed
- The coal stack should be compacted by dozers from time to time. This retards the process of oxidation
- The coal should be stacked over a network of criss cross perforated iron pipes through which water can be circulated at the slightest detection of heating
- In the coal stacks iron pipes 50mm dia pointed and closed at the lower ends should be fixed at intervals
- A thermometer can be inserted in the pipe. If temperature of pipe exceeds 60°C , it indicates spontaneous heating

Preventive measures by DGMS

- ① OB heaps → Coal face or quarry at 15m की distance रखें।
- ② quarry is abandoned → coal bench and OB dump की 6m to 10m width का trench बनाकर separate करें / ।

process of oxidation

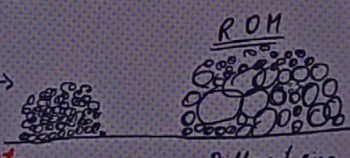
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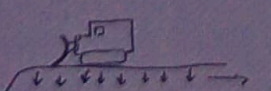
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Preventive measures by DGMS

- 1) OB heaps $\rightarrow$ Coal face or quarry at 15m distance रखें।
- 2) quarry is abandoned $\rightarrow$ Coal bench and OB dump की 6m to 10m width का trench खनकर separate करें।
 $\downarrow$
 depth $\rightarrow$ below the coal seam.
 - ① fill with water
 - ② boiler ash
 - ③ Incombustible material.

Steps to prevent spontaneous heating.

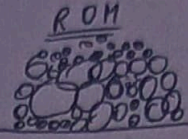
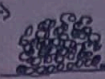
- 1) Stock करने वाला ground hard होना चाहिए
 $\downarrow$
 free from vegetation
 Concrete is best. 
- 2) Coal stock में एक ही size के Trench.
 Coal रखें $\rightarrow$ by screening 

ROM
Different size
- 3) In which of the following stocks spontaneous heating will occur the most.
 Ans $\rightarrow$ ROM
- 4) Coal के contact में shale के pieces होने के कारण s.p. heating हो सकता है, इसलिए shale के pieces को pick (छुटा लेना) कर लेना चाहिए
- 5) Coal stock में 200 tonne से अधिक coal नहीं होना चाहिए and इसकी height 1.5 से 3m के बीच होनी चाहिए
 $\downarrow$
 Critical height
- 6) Clearing of Coal stocks $\rightarrow$ First Come first removed
 $\downarrow$
 fresh coal ही रखें
- 7) Compacting of coal stocks $\rightarrow$ by dozers
 $\downarrow$
 from time to time
 Oxidation को रोकने में help करेगा

 Roller/dozer की help ground को

free from vegetation
Concrete is best.



- ② Coal stock में हवा की size के Trench.
Coal रखें → by screening



Different size

Q ⇒ In which of the following
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Ans ⇒ ROM

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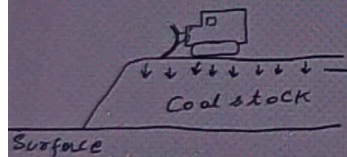
↓
Critical height

- ⑤ Clearing of Coal stocks → First Come first removed.
↓
fresh coal ही रखें.

- ⑥ Compacting of Coal stocks → by dozers

↓ from time to time

Oxidation को रोकने में help करेगा



Roller/dozer की help ground को दबाना → Compacting कहलाता है।

- ⑦ Coal stocks में 50 mm के dia के iron pipes लगाना

↓ Thermometer लगा दें

हवा से touch करने पर अगर बहुत गर्म महसूस होता या temperature 60°C से अधिक है तो यह sp. heating का indication है।



- ⑧ 100 mm के dia के bore pipes coal के stock के पास बिछा कर रखें and उसमें से 50mm के dia के branch pipes (hose pipes) से coal stock को wet करें

- ⑨ Coal stock की criss cross network वाले pipes के ऊपर बनाए जिनमें water circulate होता रहे and थोड़ा सा भी heat detect करने पर पानी डाल दें।

- ⑩ Coal stock की mud से Coating करें → oxygen supply cut कर देंगे

MINING GYAN

Remedial measures by CIMFR

- Accumulation of slack/coal in the floor of the quarry benches should be avoided
- A suitable protective coating be applied to the face of the coal bench
- Covering of coal stacks with polythene sheets 0.2mm thick restricts air feed to the coal
- A fire resistant sealant is used for avoiding air leakages in longwall faces
- Coal should not be stocked near any source of heat like boiler house, boiler ash heap, steam, pipe range

Remedial measures by CIMFR.

- Quarry के benches में slack को हटाकर ना होने दें।
- Coal के bench के face में एक protective covering कर दें।
- Coal के stacks को 0.2mm की thickness वाली Polythene से cover कर दें।
- Longwall faces में air leakage रोकने के लिए fire resistant sealant का use करें।
- heat source के पास coal को stock ना करें।
→ boiler house, boiler ash heap, steam pipe range

Dealing with fires in surface coal stock

- Steam rising from a coal stock is a warning that heating is taking place. Presence of moisture on surface of coal stock in the morning or late in the evening should not be mistaken for dew
- Seat of heating in a coal stock is nearly 0.6 to 1.5m below surface of stock
- The coal stock in which heating has started should be drenched with water jets under pressure. The quenched coal should be dug up and spread in thin layers about 0.6m thick at another place and allowed to cool down
- Fire in the CHP can be prevented by keeping a watch on the heating which may take place if the coal is not despatched due to shortage of wagons. On detection of such heating coal should be despatched by trucks where it should be treated with water

Dealing with fires in surface coal stock.

- Coal stock से steam (भाप) निकलने मतलब है कि coal में heating हो रही है।

Dealing with fires in surface coal stock

- Coal stock से steam (भाप) निकलने मतलब है कि Coal में heating हो रही है।
- Coal stock के surface पर moisture आ जाता
morning evening.
- Coal stock के surface से 0.6 m to 1.5 m तक की depth में heating होता है।
- Coal में अगर heating हो रहा है तो पानी डाल उसे बुझा दें
- बुझाने के बाद coal को गढ़ा खोदकर निकालें और किसी दूसरी जगह पर 0.6 m thick layer में spread कर दें ताकि वह cool down हो सकें।
- CHPs में कभी-कभी coal despatch ना होने पर heating होने पर उसे तुरंत ही trucks में despatch करके water डालकर cool करें।

Spontaneous heating

- It is the process of self heating resulting in its ignition without the application of external heat
- When coal is exposed to air it absorbs oxygen at the exposed surface.
- Some fractions of the exposed coal absorb oxygen at a faster rate than others and the oxidation results in formation of gases, mainly CO, CO₂ and water vapour along with heat during chemical reaction
- Process of spontaneous heating occurs at normal atmospheric temperature
- If the rate of heat dissipation is slow compared to the evolution of heat then the temperature of coal rises
- The raised temperature increases the process of oxidation.
- When the temperature reaches the point of ignition of coal then it catches fire if the air supply is sufficient
- Ignition temperature of bituminous coal is 200°C and that of anthracite is 398°C

Spontaneous heating

- Process of self heating → खुद से गर्म होने की प्रक्रिया
↓
Coal बिना किसी external (बाहरी) heat के ignite हो जाता है।
- जब coal air में exposed होता है तो वह oxygen absorb कर लेता है।

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→ Process of self heating → खुद से गर्म होने की प्रक्रिया

→ जब cool air में exposed होता है तब वह oxygen absorb कर लेता है।

→ oxygen absorb start at 0.1111 $\frac{1}{9}$ oxidation at process

$\downarrow$
 CO, CO_2 , water Vapour (स्टीम), heat.

→ Spontaneous heating normal atmospheric temperature पर ही होता है।

→ जिस Rate से heat coal से बाहर निकल रहा है उससे अधिक Rate से heat produce हो रहा है।

↓ Coal का temperature बढ़ जाता है और इसके कारण oxidation की प्रक्रिया भी तेज हो जाती है,

→ कुछ समय बाद जब temperature coal के ignition point तक पहुँच जाता है तब coal में आग लगन लगती है।

→ Ignition Point (प्रिग्निशन) $\rightarrow$ Bituminous Coal - 200°C
 Anthracite Coal - 398°C } Ignition Temperature

- **Chemical composition of coal**

- High moisture and high volatile coal are more susceptible to spontaneous heating.
- All bright coals with 25% or more of volatile matter and 7 to 15% of moisture are prone to spontaneous heating.
- Drying up of coal breaks and it causes more surface for contact with air and oxidation
- High rank of coal with high carbon is less liable to spontaneous heating
- Proneness to spontaneous heating of coal decrease with the decrease in oxygen and if the oxygen percent is less than 2% or less the coal is not liable to spontaneous heating

① Chemical Composition of Coal

→ High moisture & high Volatile (परिवर्तनशील) chances ज्यादा

कुछ समय बाद point तक पहुँच जाता है तब coal में आग लगने लगती है।
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Factors governing spontaneous heating

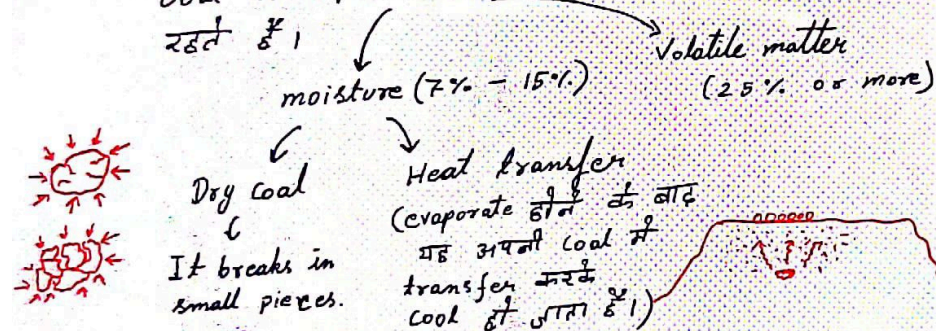
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Factors Governing Spontaneous heating

1) Chemical Composition of Coal

→ High moisture & high Volatile (परिवर्तनशील)
 Coal में sp. heating होने के chances ज्यादा रहते हैं।



→ High rank के Coal में sp. heating कम होता है।

→ Oxygen का % अगर 2% या उससे कम है तो sp. heating नहीं होगा।

• Banded constituents of coal

- The bright bands of coal i.e. vitrain and clairain are more liable to spontaneous heating than the dull constituents like durain and fusain
- Durain is hard and difficult to fracture and resistant to self heating
- Fusain consists of very largely of resistant materials but it is porous in

Banded constituents of coal

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- Durain is hard and difficult to fracture and resistant to self heating
- Fusain consists of very largely of resistant materials but it is porous in which flocculent powder is present which provides a large surface to the air
- It oxidises rapidly at low temperature but is only 5 to 6% of the coal and is not an important factor
- Flocculent powder** – It is a water soluble polymers used for flocculation in effluent treatment
- Flocculation** – It is a process by which colloidal particles come out of suspension to sediment

Banded constituents of Coal → Vitrain } more liable to sp. heating
→ Clairain }

hard and difficult to fracture ↓

इसके कारण self heating कम होता है

Durain } less liable to sp. heating
fusain }

Resistant (प्रतिरोधक) material से बना होता है।

→ यह Porous (छिद्र) होता है

flocculent Powder भरा होता है। जो self heating के लिए large surface provide करता है

Flocculent powder

water soluble polymer जिसका use treatment plants में किया जाता है।



→ **Flocculent powder**
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large surface provide करता है।



- **Friability:-** Coal which is easily crushed and broken into smaller size is more liable to spontaneous heating than hard coal
- **Presence of iron pyrites**
 - Coal containing iron pyrites in scattered form is much liable to spontaneous heating
 - During oxidation it causes oxidation in coal due to which coal breaks
 - The broken coal presents more surface for air circulation and is also slightly warmer due to the heat of oxidation of pyrites
 - It accelerates the process of oxidation
- **Nature of adjoining strata:-** If a coal heap is covered by loose shales the heat of oxidation of coal is not dissipated as fast as in the case of coverage by sandstone and the former heap is more liable to spontaneous heating

③ **Friability** → Broken / Crushed Coal → जिसका size बहुत ही छोटा होता है।

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④ **Presence of Iron Pyrites**

- इस coal जिसमें iron pyrites scattered (बिखरा हुआ) form में पाया जाता है उसमें sp. heating होने का chance काफी होता है।
- Oxidation के वक़्त यह coal की break कर देता है।
- खुद oxidation करके coal के temperature को बढ़ देगा





- **Depth of seam:-** The strata temperature and crushing effect of superincumbent rocks of a coal seam increases with increasing depth. Both the factors accelerate the process of spontaneous heating
- **Thickness of seam**
 - It is difficult to remove all the coal in a thick seam during depillaring by caving which results 50% extraction only
 - Remaining coal is in the form of stooks, coal in the roof or coal in the parting between adjacent section
 - Coal of high stooks is easily crushed and such crushed coal is readily attacked by the oxidation process
 - Slow velocity of air current in high galleries is also a reason because it does not removes heat produced by oxidation

⑤ Nature of adjoining strata

अगर coal में shale की मात्रा अधिक है तो वह heat को बाहर नहीं निकलने देगा
Sandstone के case में heat easily बाहर निकलती है

⑥ Depth of seam → strata temperature increases with depth

Superincumbent rock के कारण crushing effect होता है।
both accelerate sp. heating

⑦ Thickness of seam → Only 50% extraction is possible after depillaring.

Remaining Coal

→ stooks

oxidation is easy.

→ Superincumbent rock का दबाव crushing effect होता है।
 both accelerate sp. heating

⑦ **Thickness of seam** → Only 50% extraction is possible after depillaring.

↓
 Remaining Coal

① Stooks

② Roof

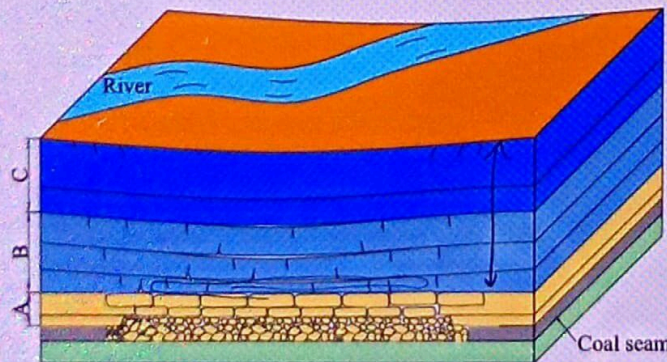
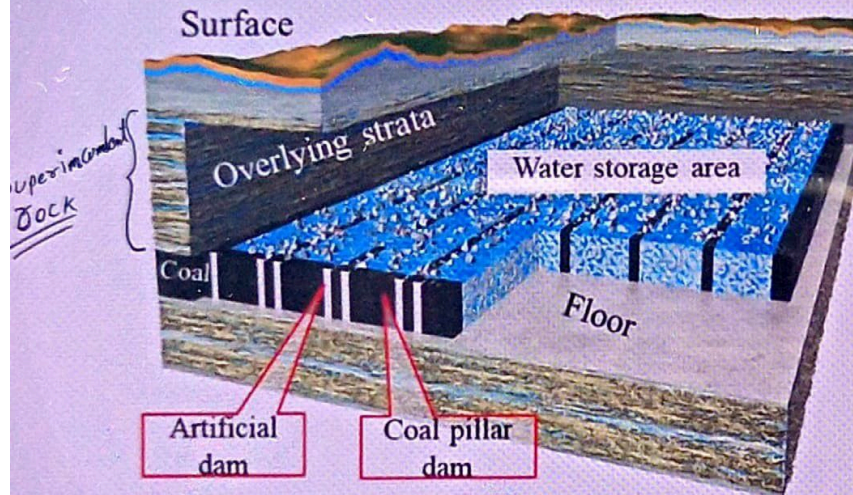
③ Parting b/w sections

oxidation is easy.

→ if stooks are very high → crushing of stooks होगा

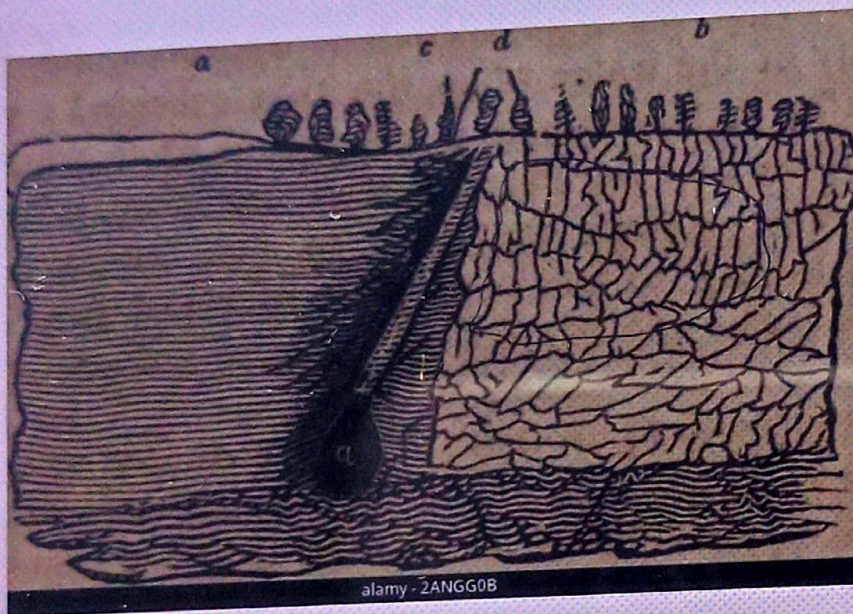
high galleries of air velocity कम होने के कारण heat remove नहीं हो पाती है

crushed stooks में oxidation भी अधिक होगा।



A - Caved zone B - Fractured zone C - Continuous deformation zone





• Geological disturbances

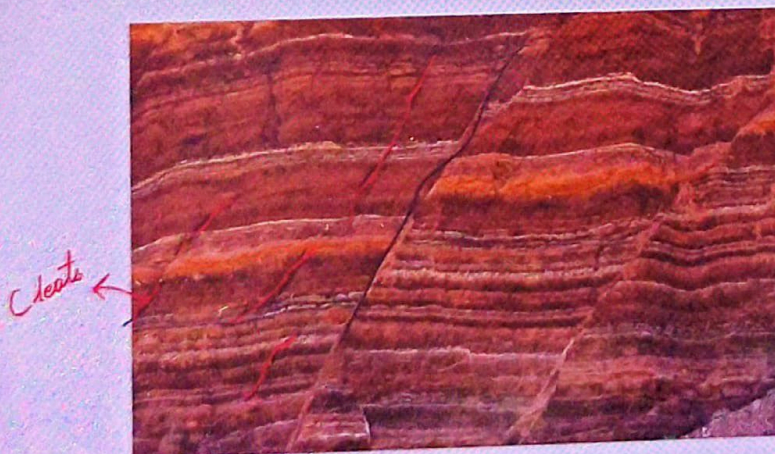
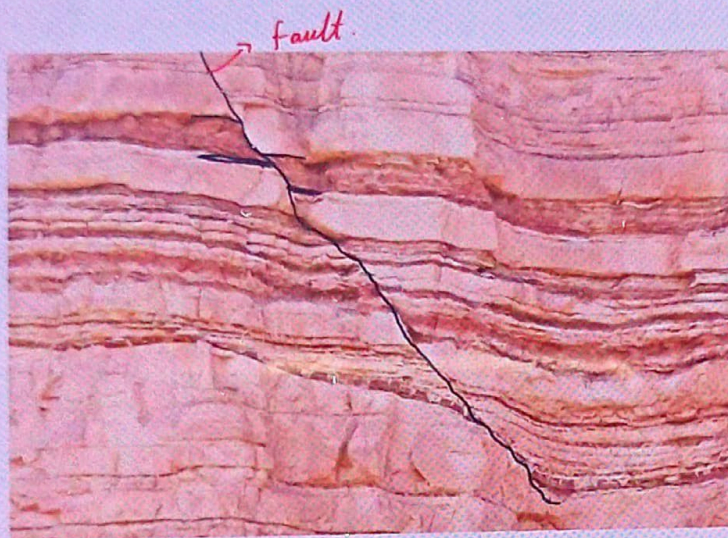
- Near fault plane the coal and other strata are usually crushed and not hard enough
- Crushed and weak, friable coal has to be left insitu for support near a fault zone to prevent a rock slide along the fault plane
- Such coal is more liable to spontaneous heating than the comparatively harder coal at places away from the fault zone

⑧ Geological Disturbances

→ fault plane के पास support के लिए pillars छोड़ने हों और अगर नहीं भी छोड़ते हैं तो fault plane में movement के कारण crushed coal पाया जाता है।

8) Geological Disturbances

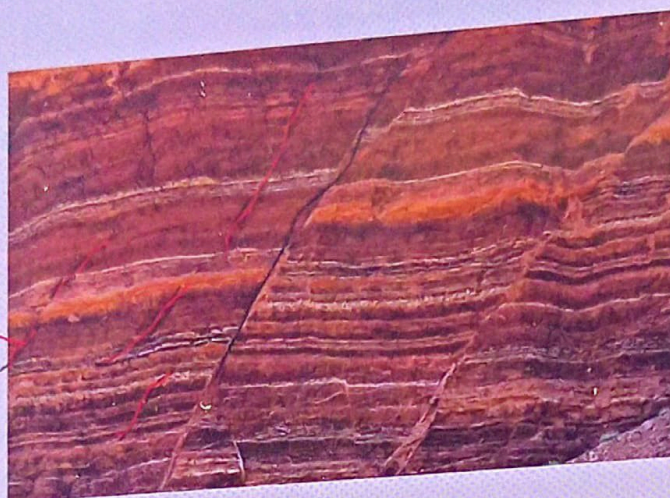
↳ fault plane के पास support के बिना pillars छोड़ते हैं और अगर नहीं भी छोड़ते हैं तो fault plane से movement के कारण crushed coal पाया जाता है।



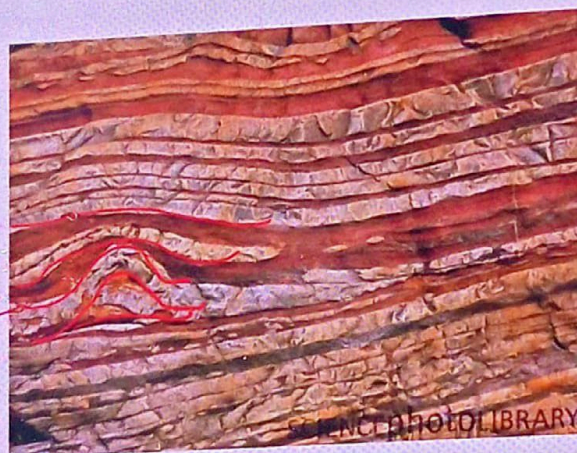
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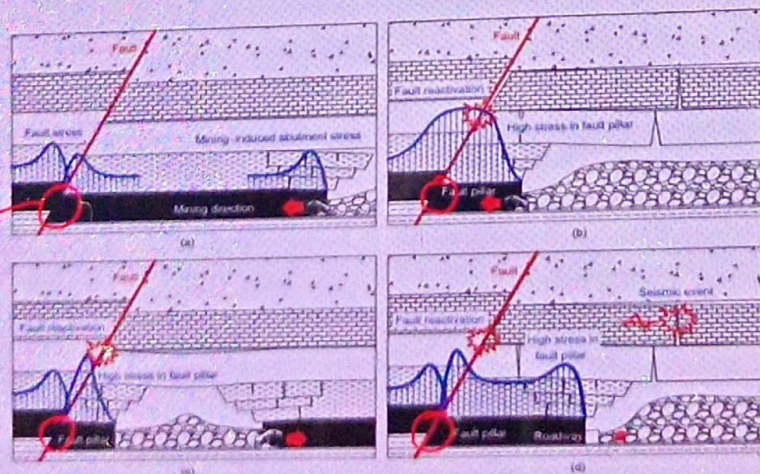
Cleats



fold



Grashed Coal



MINING GYAN

Incubation period

- It denotes the period between the time when the coal is first subjected to conditions favourable for spontaneous heating and time of indications of heating
- In depillaring with caving coal is left in stooks and is buried under broken rocks of roof after the first major roof fall
- In thick seams having shale band coal is left in roof during development and during depillaring after withdrawal of supports it falls down
- Basically first roof fall creates conditions for oxidation of coal and heat does not dissipates fastly causing spontaneous heating
- It cannot be measured by any instrument
- It varies from seam to seam

Incubation Period

- Coal के पहली बार spontaneous heating होने वाली condition में आने से लेकर उसमें heat के indications मिलने तक के बीच के समय को Incubation period कहते हैं।
- In depillaring with caving → Coal left in stooks
→ Broken rocks of roof after 1st major roof fall
- In Thick seams.
→ अगर shale band है तो roof से coal छीड़ते हैं जो कि support withdraw करने पर fall होता है।
- first roof fall → Coal के लिए oxidation करने की condition create कर देता है and heat उतना तेजी से नहीं निकल पाता है जितना तेजी से इसमें heat बनता है।
- इसे किसी भी instrument से measure नहीं कर सकते हैं।
- Different seams का different incubation period होता है।

Symptoms of spontaneous heating in UG mine

Initial stage of heating

- **Faint Haize:-** This is due to moisture given off during oxidation of coal. The moisture collects as small globules in the cooler air away from the actual seat of heating.
- **Moisture deposition:-** This is due to the condensation of moisture and its deposition as beads on the cooler surfaces (roof, sides, timber and metal surface)
- **Faint odour known as gob stink:-** The odour resembles the smell of decaying timber. There is also slight discomfort due to increase in air temperature and humidity.
- Cricket and other small insects show increased activity and chirping

संकेत।
→ Different seams का different incubation period होता है।

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Intermediate stage

- Previous symptoms are intensified and there is a further pronounced petrol like odour indicating the beginning of distillation of coal.

Last stage of heating approaching ignition

- The petrol like odour changes into tarry odour, sometimes known as **Firestink** which is also due to distillation of coal. Further stage is the actual appearance of smoke which may travel sometimes against the air current in the intake air way also.

- Smell of other materials may obscure the actual smell which arises out of self heating such smells are due to:-
 - Decay of wood in warm damp places
 - Tarred brattice cloth
 - Lubricating oil
- Dry and wet bulb hygrometer are maintained for the return airway of mine, because increased temperature especially of the wet bulb

Symptoms of sp. heating in UG mine.

1) Initial stage of heating.

(a) Faint Haize → oxidation होने पर moisture coal से निकलता है। ↓

Cool air के साथ
बादल बना उड़ेगा

(b) Moisture deposition

→ Moisture ठंडा (condense) होने पर
Cool surfaces पर बैठ जाता है।

↓ Roof, sides, timber & metal surfaces.

(c) Faint odour known as gob stink

→ timber के सड़ने की महक आने लगती है।
→ Temperature & humidity बढ़ने के कारण
→ ... होने लगता है।

① Faint odour known as gob stink

↳ timber के सड़ने की मटक भाने लगती है।
 ↳ Temperature & humidity बढ़ने के कारण discomfort महसूस होने लगता है।

↳ Cricket (झिंगुर) or बाकी के छोटें कीड़े (insects) तेज आवाज करने and इधर उधर भाने

② Intermediate stage

↳ पिछले सभी लक्षणों में तीजी आ जाइगी
 ↳ Petrol जैसा मटक भाने लगता है जो की मटक दर्शाता है की coal का distillation हो रहा है।

③ Last stage of heating

↳ Petrol वाली मटक tarry odour (मटक) में बदल जाइगा जिसे 'Firestink' भी कहते हैं।

↳ कुछ समय बाद हवा में धुँगा दिखने लगेगा

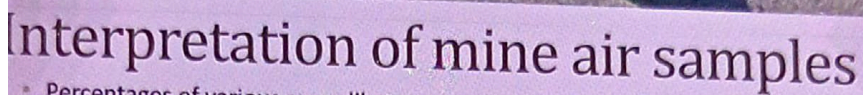
→ other smells due to

- ① Decay of wood in warm damp places
- ② Tanned brattice cloth
- ③ Lubricating oil



Interpretation of mine air samples

- Percentages of various gases like oxygen, CH₄, CO, CO₂, N₂, in the return air of a normally working mine, and at other places of suspicion.
- Existence of fire or spontaneous heating in some part of a mine
- The inflammability (or explosibility) of the atmosphere in the return side of a fire when the latter is being tackled by direct methods of fire fighting.
- The condition of fire in a sealed off area.
- In a normally working mine the slow oxidation of coal produces small quantities of CO and CO₂.
- The percentages of these gases in the return air remain nearly constant in the samples taken periodically from the return air and any unusual increase in the percentages needs immediate investigation.
- The CO₂ is produced not merely by slow oxidation of coal but by various other



Interpretation of mine air samples

- ### Interpretation of Mine air samples.

$\left. \begin{array}{l} \text{CH}_4 \\ \text{CO} \\ \text{CO}_2 \\ \text{N}_2 \end{array} \right\}$

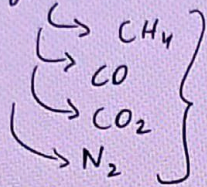
$(K_{eq} - 1)$ value remains constant

as follows: CO/O₂ deficiency: 0.1% to 0.5% is normal to a coal mine (in extreme cases only it may be upto 1%)

- 1% indicates existence of spontaneous heating
- 2% indicates heating in advanced stage approaching active fire
- 3% or more indicates active fire.

Interpretation of Mine air samples.

→ Various gases का % पता करने के लिए



→ Return air & शंका वाली जगह पर पता किया जाता है।

→ fire वाली जगह के Return air में inflammability or explosibility पता करना चाहिए अगर directly fire fighting करने जा रहे हैं तो।

→ Sealed off area में fire की condition पता चलता है।

→ Oxidation of coal → CO
→ CO₂

→ Samples return airway में collect करना है

→ % of gases remains constant
→ Unusual increase होने पर तुरंत ही investigation कर सकते हैं।

→ % of CO in return airway → 0.005
→ 50ppm } अधिक नहीं होना चाहिए

→ Indication of stages of sp. heating.

→ Grahams Ratio ⇒ $\frac{\text{CO Produced}}{\text{O}_2 \text{ Consumed}}$

→ अगर 0% working places के return airway में 0.1% to 0.5% है तो working में samples लेने 1% CO भी मिल सकता है।

→ CO not produced by → human breathing
→ burning of light
→ Decay of timber } O₂ is consumed

→ Mines में 0.1% से 0.5% तक CO normal माना जाता है।

→ Grahams Ratio

→ 1% → कभी spontaneous heating हो रहा है

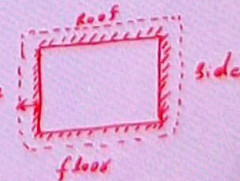
- just enough width for passage of tubs and men.
- Pre-fabricated isolation stoppings are recommended
- If the work of coal extraction in a panel is over, remove all the equipment and seal off the panel by isolation stoppings to prevent entry of air. Before such sealing the area should be heavily stone dusted.

Methods of working in coal seams liable to sp. heating

- Mines को panels में divide करके depillaring करें।
- बिना panels के developed mines में artificial panels बनाए → by brick walls.
- Dimension, shape & size of Pillars इस प्रकार का हो की crushing ना होने पाए
- अगर development करने बाद लंबे समय तक depillaring → Pillars पर stone dusting करें
→ Crumbling भी कर सकते हैं।
- Longwall Mining method → अगर without stowing कर रहे हैं तो LW retreating method से करें
- Longwall face panels में होने चाहिए ताकि emergency के case में seal किया जा सके।
- Air leakage को रोकने के लिए main intake and return के बीच large gap होना चाहिए
- Low water gauge पर परमिट Vent. होना चाहिए
- Panels में कम से कम entries रहें

which of following Precautions should be taken while working in seams liable to sp. heating?

- Isolation stopping बनाने के लिए brick and other construction material का sufficient supply रहें।
- Roof, floor and pillars में stoppings लगी से बनाने के लिए खंजा (Recess) पड़ने से ही cut करके रहें
- अगर road की width ज्यादा है तो stopping partially बनाए (Door provide कर दें)



- Panel में extraction complete होने पर heavy stone dusting करके sealed of कर दें

Prevention of UG fires

Check the workers, before they proceed underground, for match box, cigarettes, biris, cigarette lighters and other contrabands.

Do not allow burning of fires inside a mine (non-coal mine) and within 15 m of an incline/pit.

Avoid welding of the headgear pulley or the headgear frame unless proper precautions are taken. Such welding in the case of a coal mine requires previous permission of the DGMS

Avoid welding in underground repair shop without adequate precautions. If any repair shop/ workshop is to be provided underground in a coal mine prior approval of the DGMS is essential in case the repair shop is to be equipped with welding arrangements

The repair shop should be in the main intake airway near the DC shaft

Ventilation should be adequate.

Methanometers should be used to keep a watch on the percentage of firedamp during the time of welding

The welding operation should be conducted in the presence of a responsible official, preferably a senior overman, an Assistant Manager, or a Ventilation officer

Fire fighting equipment should be ready at hand

Restrict the storage of inflammable and combustible materials like oil, grease, timber, etc. underground.

Remove all wood cuttings, oily and greasy cotton waste out of the mine

Cables should therefore be laid along routes which are normally expected to be free from danger of roof-fall. Avoid cables in roads with rope haulages to prevent damage by derailed tubs.

Use electric motors, switchgears and transformers of flame-proof type in underground coal mines.

A motor of insufficient power and rating, if worked for long hours, gets too hot and the heated surface can provide a source of ignition

Use only approved safety lamps

Do not use any naked lights

Machinery used underground should be properly assembled and operated so that during use it does not cause dangerous sparks or hot surfaces

Brake blocks of underground machinery like haulage engines, locomotives, etc. should be adjusted periodically to avoid their overheating.

Avoid accumulation of dangerous electrostatic charge on equipment using compressed air by earthing

Ensure that the conveyors are in proper alignment and their idlers and rollers moving freely. The belt should not rub against any timber, metallic surface or rock.

Face machinery like conveyors, coal cutting machines and drills should be operated by remote control arrangement

Use conveyor belts made of P. V. C. which is fire resistant. The brattice cloth used for coursing the air should also be fire resistant.

Minimise frictional sparks arising from the use of coal cutters, shears and similar equipment by use of sharp cutter picks

Use only permitted explosives in underground coal mines

All the shot- holes should be carefully checked for the presence of cracks.

Do not work in a coal seam lying below a fire area or another seam on fire without permission from the D. G. M. S.

Provide barriers of sufficient thickness against existing fire in the same mine or adjacent mine

Check the underground workings, specially at the goaf edges, regularly for any unusual rise in temperature or other symptoms of spontaneous heating

Special care should be taken to see that inspections are not neglected on non-working days

In abandoned coal inclines guard against illicit distillation of liquor as such practices have been noticed in a number of mines. The fires ignited for such illicit distillation are very often not extinguished by the persons indulging in such antisocial and illegal activities.

Illicit distillation → लकड़ी के सड़ने के कारण (fermentation)

Illicit liquor → अवैध शराब

Dealing with UG fires

- Foreman/overman/assistant manager on indication of heating or fire in any part of mine should withdraw workers from the ventilating district
- Cut off electric power in that area and inform the mines manager
- One method of informing all the workers of the emergency is to pour eucalyptus oil in the intake air stream
- The mine manager on getting information of fire has to inform DGMS and nearby rescue station

Measures to deal with fire

- Quenching the fire with water, sand or with the suitable fire extinguisher
- Ventilation to the fire area is restricted by short circuiting the major quantity of ventilation
- The fire should be tackled only from the intake side and water should not be used to quench electrical or oil fires
- The quenched material is dug up and sent to the surface and the dug up area is drenched with water and allowed to cool down
- The cavity is packed with earth or sand
- During the process of the fire fighting, FSL and CO detecting apparatus should be kept at site

Digging out is possible if

- The fire is easily accessible
- Localised over a small area
- There is no danger of firedamp explosion
- The roof is good and has not collapsed due to fire
- A small accessible fire can be covered with a blanketing material like earth or sand to cut oxygen
- The blanketing has to be done not only on the burning material but also at the cracks or passages of air supply to the fire

MINING GYAN

Other methods

- Sealing off the fire
- Drowning the fire
- Flooding the fire area with inert gas

→ non-reactive gases

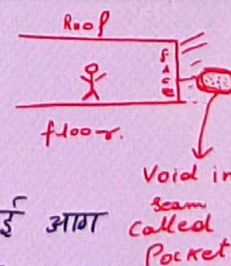
Sealing off the fire

- If the fire is inaccessible
 - In goaf area
 - Extensive
 - There is danger of firedamp explosion when dealing with it
- These areas have to be sealed off. Its main aim is to cut the supply of oxygen
- The sealing operations have to be conducted from places which will not be affected by the effects of fire like heat, smoke, CO, CO₂ etc.
- Time factor is important in sealing. Delay will cause the fire to spread over a large area and the extensive fire may go out of control resulting in abandonment of the mine
- In a gassy coal mine the fire may spread to pockets of explosive gas air mixture and result in explosion

Sealing off the fire

→ अगर आग पहुँच के बाहर है

↪ goaf area
 ↪ बड़े पैमाने पर फैली हुई आग
 ↪ जहाँ पर firedamp explosion का खतरा हो



→ उसे जगह seal कर दिया जाता है → To cut supply of oxygen

→ Sealing operation कहाँ से करेंगे?

↪ जहाँ पर fire के कारण or उसके प्रभाव ना है।
 ↪ Heat, Smoke, CO, CO₂

→ Sealing में time factor बहुत important होता है।

↪ जितना दूर करेंगे आग उतनी फैलेगी
 यह भी हो सकता है की mines को
 बंद करना पड़ जाए।

- Sealing में time factor बहुत important होता है।
 जितना देर करेंगे आग उतनी फैलेगी
 यह भी हो सकता है की mines को
 बंद करना पड़ जाय।
- In assay coal mines में आग pockets में भी
 लग सकती है जो कि air के साथ mix हो
 कर explosion कर सकता है।

Types of stopping

- ✓ Preparatory stopping
- ✓ Emergency stopping or temporary stopping
- Permanent stopping

Preparatory stopping

- It is partially constructed in the main entries leading to a district
- Before depillaring it has to be done
- After the depillaring operations are over such stoppings are made complete to isolate the depillared area then called isolation stopping
- Bricks and earth are always kept in readiness at such stopping sites
- It serves the purpose of isolation and therefore is also known as isolation stopping
- It has to be built in all mines whether depillaring with caving or stowing
- It should be provided with iron doors
- Thickness must be at least 1m in deg. 1 and 2 mines and if CH₄ % is 2% or more it must be converted into explosion proof stopping
- In deg. 3 mines only explosion proof stopping must be built

Preparatory Stopping

- Partially constructed → District के main entries पर बनाया जाता है।
 → Depillaring के पहले
- Depillaring operation के बाद इस stopping को isolation stopping बना देते हैं।
 → earth हर वक्त

- Thickness must be at least 1m in deg. 1 and 2 mines and if CH₄ % is 2% or more it must be converted into explosion proof stopping
- In deg. 3 mines only explosion proof stopping must be built

Preparatory Stopping

- Partially constructed → District के main entries पर बनाया जाता है।
↳ Depillaring के पहले
- Depillaring operation के बाद इस stopping की isolation stopping बना देते हैं।
- Stopping sites पर brick and earth हर वक्त ready रखते।
- सभी mines में इसको बनाना compulsory है
↳ Stowing / Caving.
- लौहे के दरवाजे इसमें लगाए
- अगर deg. 1 and 2 mines में methane 2% या उससे अधिक है तो इसे explosion proof stopping में बदल दिया जाएगा
- Deg. 1 & 2 में thickness 1m से कम नहीं होना चाहिए
- Deg. 3 mines में सिर्फ explosion proof stopping ही बनाना है।

Explosion proof stopping

- It consists of a pair of two brick stoppings built in cement mortar having a minimum thickness of 1m and spaced at least 4.5m
- The space between two stoppings should be packed solid with incombustible materials
- The minimum depth of locking shall be:-
 - In coal at least 1m
 - In sandstone roof/floor at least 15cm
 - In shale stone roof/floor at least 30cm

Explosion Proof Stopping

- इसमें brick की 2 walls होती हैं
↳ Thickness 1m each

Explosion Proof Stopping

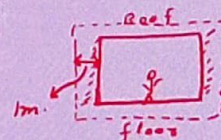
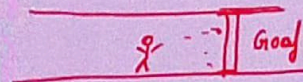
Thickness 1m each
walls के बीच 4.5m का gap (space) होता है।
↓
tilt material

↓
Incombustible material
भर दिया जाता है।

In coal $\rightarrow$ 1m

In sand stone roof/floor $\rightarrow 15\text{cm}$
 In floor $\rightarrow 30\text{cm}$

In shale stone roof/floor $\rightarrow$ 30 cm.



- It is constructed after heating or fire is detected
- Such stoppings are required where preparatory or isolation stoppings had not been constructed
- It is not necessary to construct it in development area
- Its purpose is to seal on area immediately and prevent access of air to the fire which dies down in course of time
- It also prevents the heat, smoke and fumes from reaching the places where permanent stoppings

Emergency Stopping

→ heating or fire detect होने पर इस बन्दी डै।

→ यह stoppings वहाँ नमूने हैं जहाँ पर preparatory or isolation stopping ना हो

1. 1. $\frac{1}{2}$ मरी मरी 0.5

reaching the places where permanent stoppings

Emergency Stopping.

- heating or fire detect होने पर इसे बनानी है।
- यह stoppings वहाँ बनाने हैं जहाँ पर preparatory or isolation stopping ना है।
- Development area में जरूरी नहीं है।
- fire वाली area में oxygen supply cut करनी है
- जहाँ पर permanent stopping बनाना है वहाँ heat, smoke or fumes ना पहुँची
- इसी जगह पर बनाइ जो ground movement or cracks से free हो।
- अगर cracks वाली जगह पर बनाना है तो cracks को seal कर दें।
 - ↳ By Guniting
 - ↳ By spraying latex → plastic वाला substance.

Sealing a fire in a non gassy mine

- Immediately stop air supply to the fire by construction of temporary stoppings in the intake and return roads of the district and in other roads through which air may have access to the fire

Construction of temporary stopping

- Made by nailing wooden planks to timber props
- Made of CGI sheets fastened to timber or rail props and having piles of sand or stone dust bags behind them
- If stone of ripping is available UG, a packwall of stone plastered with earth or cement
- A stopping consisting of a close knit wire mesh stretched across the roadway and sprayed with Latex

Sealing a fire in a non gassy mine

- air supply रोक दें → temporary stopping बना कर
 - ↳ Intake & Return roads में जहाँ से भी air आता तक पहुँच रही है।

Construction of Temporary stopping

(Intake & Return roads में
जहाँ से भी air भाग ले
पहुँच रही है।

Construction of Temporary stopping

- Timber props में iron nail (कील) की help में wooden planks का use।

Necessity of emergency stopping

- Stores should have adequate stocks of bricks, cement, CGI sheets, rails, sleepers, empty cement bags, stone dust etc.
- Haulage track should be extended to the stopping site for transport of heavy quantities of bricks, cement, sand, earth etc.
- Work of stopping construction should be done by workers who should not do work overtime

Equipment's at the site of stopping

- Flame safety lamps for detection of CH₄
- Birds for detection of CO
- Sufficient stone dust and fire sealing materials like bricks, cement, sand, earth and tools of masons, carpenters, miners and other workers
- First aid boxes and stretchers
- Extra electric cap lamps as some may become

Permanent stopping

- It is of brick in cement or lime are constructed outbye of the temporary stoppings after a lapse of nearly 48 hours
- It is the last step to seal off an area and the work should be reliable
- The sites of permanent stoppings are selected at places free from cracks and having the minimum cross section
- The thickness of stopping is nearly 1m near the roof and it increases by 15cm for every 3m of

- The sampling pipe should pass through the temporary stopping and should extend about 3m beyond it towards the fire side
- One design of sampling pipe consists of 5cm dia and 1.5m long grouted in the stopping and provided at its outbye end with a socket which takes a brass plug
- In the brass plug is fitted a 6mm dia copper tube which is 2m in length and it extends at least 4.5m at the inbye of stopping and supported on a brick pillar
- To record the temperature of the atmosphere behind the stopping a 50mm dia pipe is fitted in the stopping
- Water seal at the floor level for drainage of water
- Water seal consists of a piece of pipe built into the brickwork at floor level with a bend at its outbye end which dips into the water contained in a small reservoir
- The reservoir may be a ditch cut in the floor or a small brickwork tank
- The pipe is a ditch cut in the floor or a small brickwork tank

Permanent stopping

- Brick, cement/lime से permanent stopping की temporary stopping बनाने के 48 hours बाद बनाया जाता है।
- Permanent stopping किसी भी area को seal करने का last step है।
- Site of Permanent stopping $\rightarrow$ free from cracks $\rightarrow$ minimum cross section
- Thickness roof के पास 1 m होनी चाहिए and हर 3 m की height पर 15cm thickness बढ़ाएंगे

fittings of fire stopping

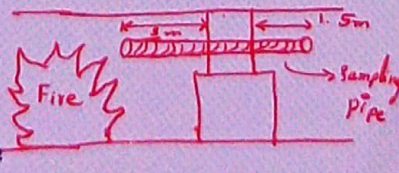
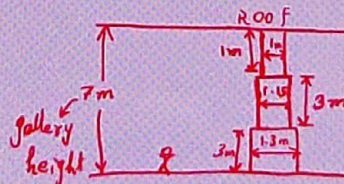
- Water gauge
- Thermometer

- Sampling pipe $\rightarrow$ dia 18mm

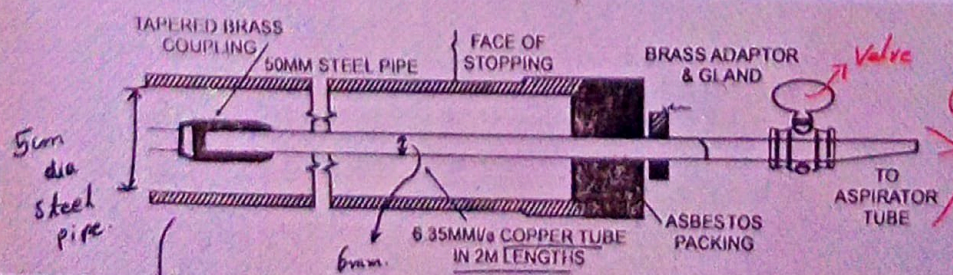
→ एक valve लगा होना चाहिए ताकि stopping के पीछे से air samples collect कर सकें

- आग की तरफ stopping 3m आगे तक sampling pipe extend होना चाहिए

- बाहर की तरफ sampling pipe
dia 5cm
length - 1.5m



- Brass plug fitting वाला sampling pipe $\rightarrow$ 2m की length वाली pipes को brass plug से जोड़ते हैं।



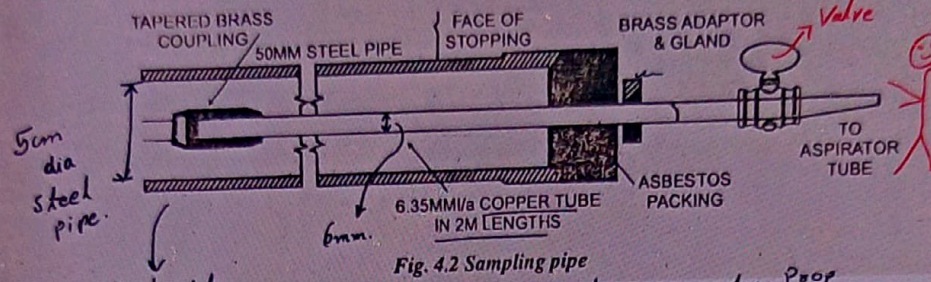


Fig. 4.2 Sampling pipe

- water seal → floor level पर लगा होता है।
 ↳ water drainage के लिए लगा होता है।
 इस pipe floor level पर fire side से बाहर की तरफ इस गट्टे से निकलती है जिसमें पानी भरा होगा
- Number plate
 ↳ entry should be maintained for 3 months
- Signature board
 ↳ signed by Overman.
 ↳ Inspection every 7 days

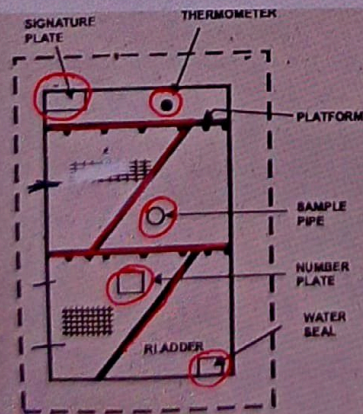


Fig. 4.3 Fire stopping in a thick seam

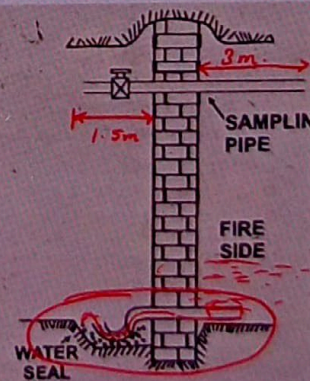


Fig. 4.4 Water seal

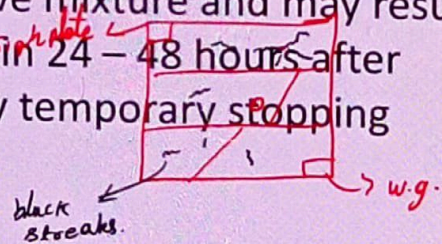
Position of sampling pipe in a stopping

- The atmosphere behind the stopping is still and the gases do not diffuse
- The heavier gases like CO₂ settle to the floor level and the lighter gases like methane remain at higher level
- The height of the sampling pipe must be between $\frac{1}{2}$ and $\frac{3}{4}$ of the stopping height
- It should extend at least 3m inside the stopping and to prevent its bending, should be supported on a brick pillar or a wooden prop
- If there is any leakage of air through the stopping, it is noticed by black streaks indicating deposit of soot or smoke at the cracks
- Stoppings should always be kept whitewashed on the surface and at the roof, floor and sides for 1m outbye for easy detection of such cracks
- Increase of temperature behind the stopping indicates leakage of air into the sealed off area
- There may be a hissing sound at the cracks if the leakage is heavy

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- After the construction of stopping oxygen decreases and methane increases which creates an explosive mixture and may result in gas explosion within 24 – 48 hours after sealing the area by temporary stopping



Position of sampling pipe

→ stopping के पीछे का atmosphere स्थिर रहता है

(gases diffuse नहीं होती हैं)
(mix)

→ floor के पास CO_2 & roof के पास CH_4 collect हो जाइगा

→ floor level से stopping height के $\frac{1}{2}$ or $\frac{3}{4}$ th की height पर लगाइंगे

→ stopping leakage होने पर cracks के आस पास black streaks बन जाती हैं

→ cracks को easily detect करने के लिए white washing करें

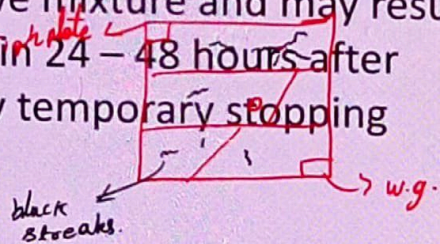
→ roof, floor, sides → upto 1m outbye.

→ temperature increase होने पर stopping में leakage होता है।

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→ roof, floor, sides → upto 1m outbye.

→ temperature increase होने पर stopping में leakage होगा है।

Sealing off a fire in a gassy mine

- The work of fire in gassy mines should be done by workers trained in the use of rescue apparatus and a rescue team with self contained breathing apparatus should be kept in service
- At the stopping sites, selected after due consideration of the points stated earlier, robust stoppings 4m thick, of sand bags are constructed
- During the construction the affected area is heavily stone dusted
- Sufficiently large area near the fire is enclosed by the stoppings so that a large volume of air is trapped behind them
- This ensures that when the stoppings are being constructed there is enough air near the fire to prevent formation of explosive gas air mixture and normal quantity of ventilating air should be allowed to reach the district by keeping the fan at the usual speed
- During the construction of fire stopping air supply to the fire area is maintained by providing two steel pipes nearly 400mm dia
- At the time of final sealing of the stoppings the two steel pipes are closed by pulling slipping falling over CGI sheets backed by steel rails are erected on the fire side of the stopping
- Two holes 400mm dia are left in the CGI sheets for air tubes in addition a hole 50mm dia is left for the sampling pipe
- The sand bag stopping is reinforced on the inbye side by CGI sheets propped up by vertical rails or props
- A sampling pipe with valve has to be provided on the robust sand bag stopping
- Final sealing of the stoppings, one on the intake side and the other on the return side is effected simultaneously with the help of synchronised wrist watches
- After the sealing all the workers engaged on the job should be withdrawn out of the mine
- There is possibility of gas explosion within 24 – 48 hours of sealing and the mine conditions should be watched during the period
- After the expiry of 48 hours air samples from behind the stoppings should be drawn and analysed on the surface
- In deg.3 gassy mines the stoppings should be reinforced on the outbye side with brick stoppings of explosion proof design equipped with the fittings of permanent stoppings

Sealing off a fire in gassy mine

→ gassy mines में आग को seal करने का काम trained workers के द्वारा किया जाना चाहिए

↓
Use of rescue apparatus

→ Rescue Team with SCBA

→ Stopping site पर 4m thick sand bag stopping बनाना है।

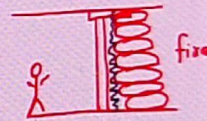
→ Stopping बनते समय fire affected area में heavy stone dusting करना है।

→ fire के आस पास stopping की help से large area provide करें ताकि large volume of air stopping के पीछे रहे

→ fire stopping बनते समय fire area में air 400mm dia वाली 2 steel pipes से provide किया जाता है।

→ जब stopping finally seal करना होता है
↓
CGI sheets से बंद कर देते

- fire stopping बनाने समय fire area में air 400mm dia वाले 2 steel pipes से provide किया जाता है।
- जब stopping finally seal करना होता है तो इन pipes को CGI sheets से बंद कर देते हैं।
- 50mm के dia का hole stopping में छोड़ते हैं for sampling pipe.
- Sand bag stopping के पीछे CGI sheet लगा कर vertical props से दबाव बना देना है।
- Sand bag stopping में sampling pipe fit करना है।
- Intake & return side में stoppings की final sealing ठीक साफ करने के बाद सभी workers को withdraw कर लेते हैं।
- 24-48 hours तक after sealing mines की condition पर नजर रखना है क्योंकि explosion होने का chance रहता है।
- 48 hours के बाद stopping से air samples ले कर surface पर analysis करेगा।
- Deg. 3 gassy mines में explosion proof stopping बनाया जाएगा with permanent stopping fittings



Sampling

- Samples of atmosphere from behind the stoppings should be collected at the following intervals
- 48 hours after sealing – 8 hours interval
- When O₂ falls to 10% or low and methane rises to 16% or more – 24 hour interval
- When O₂ falls to 5% or less and methane rises to 30% or more – 48 hour interval or longer
- Air samples from behind the stoppings should be drawn during periods of low barometric pressure, such as between 12 noon and 2PM
- The samples are collected in sampling bottles which are vacuum sealed or in other bottles by water displacement

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Sampling

→ Sampling from behind the stopping at intervals

- stopping interval of 48 hrs etc → every 8 hours
- if O₂ falls to 10% or less
&
CH₄ rises to 16% or more } → every 24 hours
- if O₂ falls to 5% or less
&
CH₄ rises to 30% or more } → every 48 hours
or
longer intervals

Breathing fire stopping

- In a sealed off fire area as the oxygen of the trapped mine air is consumed its pressure becomes less than the atmospheric air in the mine and fresh air leaks into the fire area
- This is called breathing
- Change in the barometric pressure may also result in breathing
- If the pressure inside the sealed off fire area is positive due to emission of firedamp from the strata it will cause foul gasses to leak out of the stoppings
- The leakage is usually small and cannot be prevented
- If the stopping is whitewashed and the leakage is through small cracks in it, hair like black lines of fine coal dust deposited on the cracks during leakage of air indicate the patches to be repaired
- Depillared areas of the shallow mines are invariably connected through surface cracks which have to be sealed by blanketing with inert material like earth or sand layer of 3m thickness

Breathing of fire stopping.

- Sealed off fire area में oxygen consume होने कारण वहाँ का pressure atmospheric pressure से कम हो जाता है जिसके कारण fresh air leak हो कर fire area में जाता है।
- Barometric pressure change होने पर भी breathing होता है।
- अगर sealed off fire area में pressure अधिक है तो गंधी (foul) gases fire area से leak हो कर stoppings से बाहर आता है।
- stopping की whitewashing करने
 - ↳ अगर कहीं भी leakage है तो black lines वहाँ पर बन जाइंगी
 - ↳ cracks पर coal dust इकट्ठा हो जाइगा

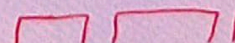


Quenching fire from surface

- Underground roadways are correctly correlated on the surface and 200mm dia boreholes 600mm apart were drilled from the surface with the help of well hole drills to join with the UG galleries
- Each gallery which was selected for construction of fire stopping, received nearly 21 bore 7 in each row across the width of the gallery
- The number of holes depended upon the height of the gallery upto the roof
- Liquid cement mortar was then injected down the hole at a high pressure
- The stone chips and the liquid cement mortar when consolidated resulted into a good seal against the fire

Quenching fire from surface

- surface से 200mm dia के boreholes drill करेंगे
 - ↓
 - 600mm की distance पर
 - ↓
 - To join UG galleries.

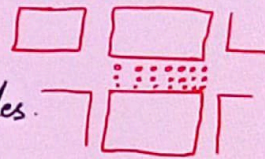


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Quenching fire from Surface

→ surface से 200mm dia के boreholes drill करेंगे
 ↓
 600mm की distance
 To join UG galleries.

→ selected gallery
 ↳ nearly 21 boreholes.
 7 in each row.



→ No. of holes depends on gallery height.
 → Liquid cement mortar holes से inject करना है।

→

Sealing the shaft

- If the shaft mouth has to be sealed to prevent entry of air into the mine on fire, the seal has to be built below the connection of the shaft with the surface fan drift
- Holes are made in the shaft wall for placing steel rails
- Over the steel rails are placed CGI sheets and a layer of concrete about 1m thick

Flooding the mine with water or inert gas

- If the explosion damages the headgear then fire is quenched by flooding or by sealing the mouth of the shaft
- Water cools down the UG strata faster than in the case of a fire quenched by fire stoppings and reopening of the sealed area need not wait for long

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- Water cools down the UG strata faster than in the case of a fire quenched by fire stoppings and reopening of the sealed area need not wait for long
- The method can be adopted if
- Sufficiency of water near the mine
- Outbreak of fire on the dip side of the mine
- Non existence of goaves on the dip side connected to other mines
- Non existence of connecting galleries to other seams or other mines
- Sufficient thickness of barrier against the mine on the dip side to withstand water pressure
- No possibility of dangers from land slides
- In shallow mines, there is danger from the land slides if the mine is flooded

Reversal of ventilation after fire

- If a fire takes place in or near the DC shaft, smoke and fumes are carried by the ventilating current inbye to the working faces and endanger the men working at the faces
- The smoke and fumes will soon travel to the main return and make the return airway unsafe as an escape route
- Reversal of ventilation in deg.2 and 3 mines is a major decision which only the mines manager should take after the occurrence of a fire or explosion
- The reversal of ventilation may be advantageous if a fire is in the DC shaft or in its vicinity in the main intake airway.
- The reversal prevents the smoke and fumes from reaching the working faces where majority of the workers may be present.
- The reversal results in throwing open the separation doors between the DC and UC shafts and also other ventilation doors between the intake and return airways.
- This causes short circuiting of ventilation and steps should be taken to see that the separation doors and ventilation doors are kept closed.
- The nearest ventilation stopping inbye of the fire side should be broken to short circuit air after reversal.
- If the mine is ventilated by a forcing fan, the reversal results into exhaust ventilation and in Degree-II and Degree-III gassy mines, reversal may cause movement of large bodies of gas from goaves and old workings into the main intake airway and from there, over the fire with consequent risk of explosion.
- In a deep mine ventilated by an axial flow fan the latter may not be able to develop sufficient water gauge after reversal to counteract the N. V. P. in winter and reversal would not prove effective.

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Explosion $\Rightarrow$ जब कोई चीज बहुत तेजी से जलती है
 And उसके साथ large quantity में heat energy
 release होती है, Original Product $\rightarrow$ gas
 $\rightarrow$ solid substance (coal dust)
 $\downarrow$
 gaseous products में convert हो
 जाता है,

Explosions In Coal Mines

- $\hookrightarrow$ ① Fire damp
- ② Coal dust
- ③ water gas

Fire damp $\rightarrow$ Major Cause of explosion in coal mines

$\hookrightarrow$ अगर air में 5.4% से 14.8% में मौजूद है तो
 यह एक explosive mixture है,

$\hookrightarrow$ अगर इसे suitable source of
 ignition मिला तो यह ignite हो
 जाएगा

$\rightarrow$ $\text{CH}_4 \rightarrow 2\% - 75\%$ तक methane को ignite
 कर सकते हैं

$\rightarrow$ explosive nature of mixture $\rightarrow$ $\text{CH}_4 \rightarrow 5.4\% \text{ to } 14.8\%$
 $\text{O}_2 \rightarrow 12.5 \text{ to } 20.99\%$

$\rightarrow$ Black damp $\rightarrow$ अगर 35% से अधिक
 atmosphere में मौजूद है तो fire damp का 1% कितना भी हो
 atmosphere non-explosive ही रहेगा

Explosive Mixture of Gases

$\hookrightarrow$ Gases का वह mixture जो कि explode होने
 के लायक

$\rightarrow$ एक बार ignite करने पर जो flame को
 पूरे mixture में खुद ही फैला देगा मने
 ही इसे source of ignition से अलग कर
 दिया गया है।

$\rightarrow$ यह mixtures inflammable mixtures के नाम
 से भी जानें जाते हैं।

Flammable $\rightarrow$ इसी चीजें जिन्हें जला सकते हैं।

Inflammable $\rightarrow$ इसी substance जो कि बिना ignition के भी
 burst हो कर आग पकड़ने की क्षमता रखता है

$\rightarrow$ Fire damp का maximum explosive violence mixture
 9% पर होता है।

Lower Limit of Explosibility

$\rightarrow$ for mixture of CH_4 & other hydrocarbons.

→ अगर हम available source of ignition मिला तो यह ignite हो जायेगा

→ $CH_4 \rightarrow 2\% - 75\%$ तक methane को ignite कर सकते हैं

→ explosive nature of mixture → $CH_4 \rightarrow 5.4\% \text{ to } 14.8\%$
 $O_2 \rightarrow 12.5 \text{ to } 20.9\%$

→ Black damp → अगर 35% से अधिक atmosphere में मौजूद है तो firedamp का % कितना भी हो atmosphere non-explosive ही रहेगा

Explosive Mixture of Gases

→ Gases का वह mixture जो कि explode होने के लायक

→ इसके बार ignite करने पर जो flame की पूरे mixture में खुद ही फैला देगा मूल ही उसे source of ignition से अलग कर दिया गया है।

→ यह mixtures inflammable mixtures के नाम से भी जानी जाती हैं।

Flammable → उसी चीजें जिन्हें जला सकते हैं।

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→ Firedamp का maximum explosive violence mixture 9% पर होता है।

Lower Limit of Explosibility

→ for mixture of CH_4 & other hydrocarbons.

→ Le Chatelier Formula

$$X\% = \left[\frac{100}{\frac{P_1}{N_1} + \frac{P_2}{N_2} + \frac{P_3}{N_3} + \dots} \right]$$

where, P_1, P_2 & $P_3 \Rightarrow$ % of each content in mixture

N_1, N_2 & $N_3 \Rightarrow$ Lower explosion limit of each Component.

$X\% \Rightarrow$ Lower limit of explosibility

Foreg → Mixture of gases emitted from a mine.

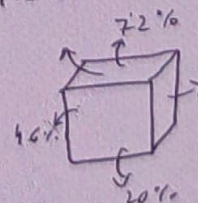
① 80% methane

② 10% hydrogen

③ 10% ethane

$$X = \frac{100}{\frac{80}{5} + \frac{10}{4.1} + \frac{10}{3.2}}$$

$\Rightarrow 4.6\%$



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Shock Waves after explosion

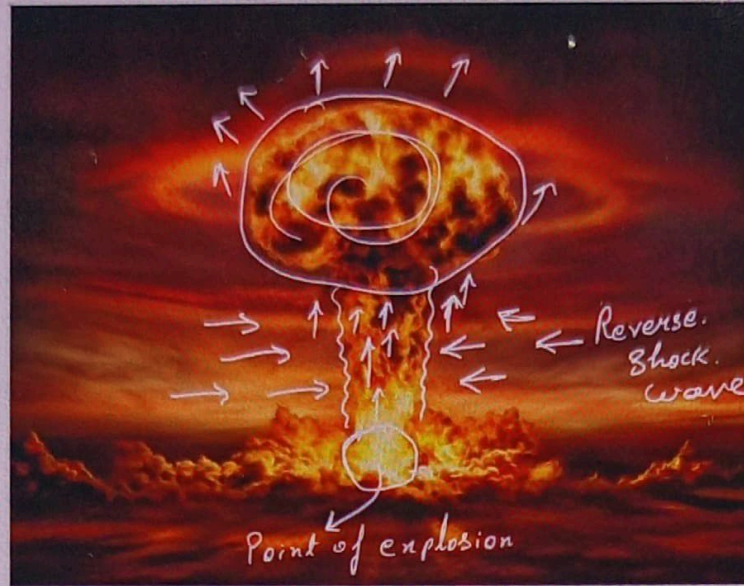
- Methane explosions are always accompanied by two shock waves.
- The forward shock wave caused by the heated gaseous products of the explosion under high pressure creating an air wave of a considerable force travelling rapidly away from the point of explosion
- The second or reverse wave which results from the pressure drop at the point of explosion because of the cooling of gases and the condensation of the water vapour (occupying a considerable part of the volume of the explosion products).
- The reverse wave is of a rather smaller force than the primary wave, but it follows the course just traversed by the first wave.
- The forward shock wave precedes the flames of explosion which consumes all the oxygen of the air.

Shock Waves after Explosion

- Methane explosion में 2 shock waves होती हैं
- ① Forward shock wave
 - ② Reverse shock wave
- Forward Shock wave
- ↳ Also called primary shock wave
- ↳ Explosion के कारण जो गर्म gaseous products release होते हैं इस वजह से यह shock wave बनता है।
- ↳ high pressure air wave है
- ↳ Point of explosion से high pressure के साथ यह बहुत तेजी से दूर भागता है।
- Reverse Shock Wave → Point of explosion से
- ↳ Also called Secondary Waves
- ↳ Pressure drop होने कारण यह होने की मिलता है
- ↳ forward shock waves के Path की ही follow करता है लेकिन towards the point of explosion
- ↳ Gases के ठंडा होने के कारण pressure drop होता है।
- ↳ Gases के ठंडा होने का कारण Condensation of water Vapour.
- Forward shock wave में भाग होती है जो की Oxygen को consume करता है।

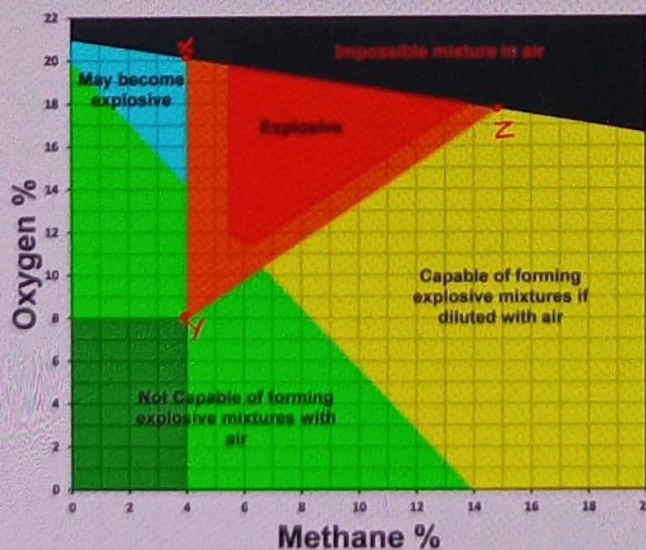


किसी Condensation of water Vapour.
 Forward shock wave की आग होती है जो की Oxygen को consume करता है,



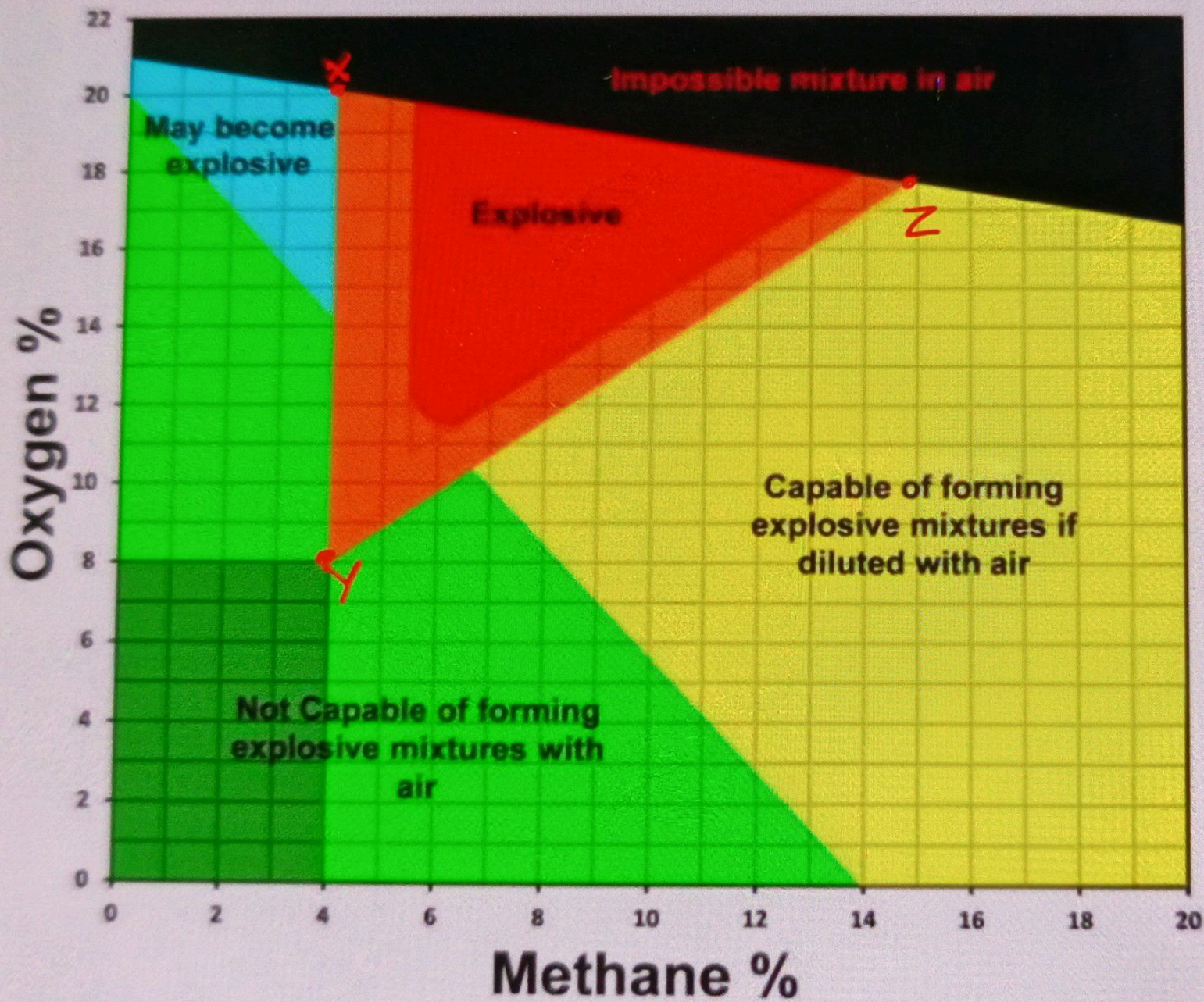
Cowards Diagram

- If fire damp present in an area is below 5.4%, it will burn away when flame is applied to it.
- The gas is then combustible.
- If gas is present in air above 5.4% application of flame or source of heat of sufficient intensity will cause the mixture to explode.
- It has significance when sealing off a fire in a gassy mine and also when reopening a sealed off a fire in a gassy mine and also when reopening a sealed off area.

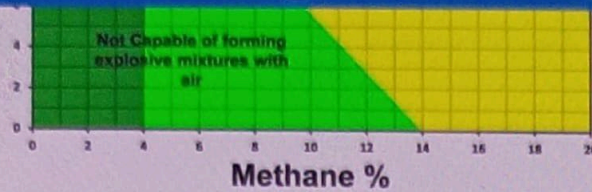


Cowards Diagram

- > किसी भी जगह पर अगर 5.4% से कम CH_4 है तो वह flame देने पर जलना
- > C.H. gas is combustible



Towards Dinnam



Coward's Diagram

- किसी भी जगह पर अगर 5.4% से कम CH_4 है तो वह flame देने पर जलेंगा
- CH_4 gas is combustible
- अगर 5.4% से अधिक methane है तो heat मिलने पर mixture explode करेगा

Important points of Coward diagram

- All mixtures lying within the triangular area XYZ, are in themselves explosive.
- All mixtures lying to the right of PYZ contain too much methane to explode but they will form explosive mixtures when mixed with the right amount of air.
- All mixtures lying to the left of PYX are neither explosive nor capable of forming explosive mixtures with air.
- Lower limit of explosibility remains almost constant at about 5.4% for all percentages of oxygen down to about 12.5%.
- The higher limit of explosibility gradually decreases from 14.8% to about 6% with decreasing percentage of oxygen.
- No percentage of fire damp is explosive when the percentage of oxygen is 12 or less.
- A firedamp-air mixture may become explosive when diluted with an appropriate quantity of air which brings the new mixtures within the limits of the triangle XYZ.

Important Points of Coward diagram.

- XYZ के अंदर का mixture explosive nature का होगा
↳ Triangular region
- Right of XYZ → Methane का % अधिक है
↳ Air मिलाने पर methane % घटेगा and within triangular region आ जायेगा
वह explode नहीं करेगा
- Left of XYZ → यह ना ही explosive है and ना ही air mix करने पर explode करेगा
- 12% से कम O_2 होने पर methane कितना भी % हो explode नहीं करेगा।

Ignition Temperature

- The ignition temperature of methane is the lowest temperature to which methane-air mixture must be raised in order to set the mixture aflame.
- It is usually taken as 650 to 750° C.
- It depends upon the intensity of heat of the igniter, the methane content of the air, the presence of various impurities in methane and the pressure under which the gas-mixture

क्षी explode नहीं करेगा)

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- The most characteristic property of methane is that when in contact with a hot source, it ignites, not immediately but with a delay, that is, after an interval of time which depends on the temperature of the hot source.
- At 650°C the delay is ten seconds, at 1000°C it falls to one second.
- It is considered that methane begins to burn only after it has absorbed an appropriate amount of heat (22.1 kcal/mole).
- This is the reason for lag on ignition of methane, the presence of hydrogen and other combustible gases in methane reduces the delay on ignition.
- The presence of 30% hydrogen in methane eliminates the delay completely.
- The lag on ignition has an important bearing on the design of safety appliances in gassy mines as will be explained later.

Ignition Temperature $\rightarrow$ वह lowest temperature जिस पर CH_4 आग पकड़ ले

$\rightarrow$ Ignition Temperature of methane $\rightarrow 650^\circ\text{C}$ to 750°C

$\rightarrow$ लेकिन ignition temperature depends on

- ① Intensity of heat
- ② Methane content
- ③ Impurities in methane
- ④ Pressure under which gas mixture is confined.

$\rightarrow$ hot source के contact में आने पर methane तुरंत आग नहीं पकड़ता है। उसमें कुछ seconds के delay से आग लगती है।

$\rightarrow$ Lag On Ignition $\rightarrow$ किसी भी चीज में आग लगाने पर उसे आग पकड़ने में जितना भी समय लगता है उसे lag on ignition कहते हैं।

eg $\rightarrow$ फुलझड़ी

$\rightarrow$ At 650°C methane gas 10 sec की delay से जलेंगा

$\rightarrow$ At 1000°C methane gas 1 sec की delay से जलेंगा

$\rightarrow$ At 1200°C methane gas $\frac{1}{10}$ sec की delay से जलेंगा

$\rightarrow$ Methane gas तभी जलता है जब उसे लगभग 22.1 Kcal/mole heat मिलता है।

$\rightarrow$ Hydrogen की presence में CH_4 का lag on ignition घटता है

$\rightarrow$ At 30% hydrogen methane का delay पूरी तरह से $\rightarrow$

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$\rightarrow$ At 30% hydrogen methane का delay पूरी तरह से खत्म हो जाता है।

$\rightarrow$ Safety appliances की design करने में lag on ignition एक major role play करता है।

MINING GYAN

Prevention of Firedamp Explosion

→ ऐसी किसी भी जगह को adequately ventilated नहीं कर सकते हैं जहाँ पर

① Methane gas is 1.25% in General body of air.

② Methane gas is 0.75% in return air.

→ अगर किसी ventilating district में 0.8% से अधिक methane है तो वहाँ daily air samples लिहा जाइंगे जब तक कि 0.8% से कम ना हो जाय

→ Ventilating district में 1.25% से अधिक methane होने पर electric power cut कर दिया जाता है।

→ Approaching a Geological Disturbance

→ In Deg. 2 & 3 mines → Within 30m no working shall be done

In Deg. 1 mines

→ Within 30m galleries की nearest Ventilation connection 3m से आगे नहीं ले जाना है जब तक sufficient air within 3m of face ना provide करा है।

→ Source of Ignition

→ Flameproof → Motors, Switchgear, Transformer जिस equipment का Voltage 25 Volt से अधिक होता है

→ apparatus का design इस प्रकार का होता है की machine के अंदर अगर gas explosion होता है तो उसके ऊपर लगा cover flame को बाहर नहीं आने देता and apparatus surface को भी ठंडा रखेगा

→ Intrinsically Safe Apparatus → जिस equipment का Voltage 25 Volt से कम होता है।

→ Signalling bells, telephones, exploder Relay

- Intrinsically Safe Apparatus → जिस equipment का Voltage 25 Volt से कम होता है।
 ↳ Signalling bells, telephones, exploder, Relay
 → इन apparatus का design इस प्रकार का होता है की इनके द्वारा spark किहा जान पर spark में इतनी क्षमता नहीं होती है कि methane को ignite कर सकें।

Coal Dust Explosion

- जब coal dust air में cloud के form में suspended रहता है तो उसमें इतनी क्षमता होती है की fire damp के बिना भी explosion करेगा।
- Explosion to be done Coal dust
 ↳ ① formation of cloud in air
 ② cloud इतना घना होना चाहिए की आँखों से उसके आर-पार न दिखे
 ③ Density of cloud → 30 to 40 g/m³
- एक बार coal dust explosion start हो गया तो 1 g/cm³ की density भी explosion करने के लिए sufficient है।
- 1 g/cm³ → इतनी coal को अगर 2.4 m × 2.7 m की gallery के periphery में बिछाए तो normal paper की thickness के बराबर एक layer बिछा सकते हैं।

→ Ignition Point → 700 - 800 °C

→ Inflammability of coal dust → It is defined as its ability to cause a flame to spread away from the source of ignition.

Coal dust की वह क्षमता जिससे की वह flame को source से दूर तक spread कर सकता है।

→ Lower Limit of Inflammability of coal dust → 1 g/cm³

→ Higher limit of Inflammability of coal dust

↳ यह एक बहुत ही ज्यादा thick cloud होगा जो की mines में possible ही नहीं है।

MINING GYAN

→ Inflammability of Coal Dust Depends Upon :-

① Percentage of Volatile matter

→ Increases inflammability
अगर 13% से कम VM है तो coal dust flame spread नहीं करेगा

② Fineness of Particles → coal dust के particle जितना fine (छोटा) होगा inflammability उतना अधिक होगा
→ $\frac{1}{10}$ mm से $\frac{1}{15}$ mm के size वाले particles को fine consider किया जाता है।

③ Percentage of Incombustible matter (IM)

→ Moisture & ash are incombustible matter in Coal dust.
IM heat को absorb कर लेता जिसके कारण Coal dust को ignite करने वाला temperature कम हो जाइगा

→ This is the principle of stone dusting

④ Presence of Moisture

→ cloud का formation नहीं हो पाइगा
Quantity → Coal dust के particles को बाँध देता है। (bind)

→ at least 30% moisture in mixture of Coal dust & moisture

⑤ Presence of fire damp → It increases inflammability

→ for every 1% fire damp at least 10-14% stone dusting increase करना पड़ता है।

⑥ Nature & Intensity of Ignition source

→ High temperature will ignite faster

⑦ Age of Coal dust → weathered coal dust ज्यादा

inflammable होता है because उनमें O_2 की मात्रा अधिक होती है।

Prevention of Coal dust Explosion

① faces में coal dust के formation को reduce करें

→ By Water → LW face में 45° के angle पर

② Age of coal dust $\rightarrow$ weathered coal dust is inflammable ही है because इनमें O_2 की मात्रा अधिक होती है।

Prevention of Coal dust Explosion

- ① faces में coal dust की formation को reduce करें
- $\rightarrow$ By Water $\rightarrow$ LW face में 45° के angle पर holes drill करके highly pressurised water को डालते हैं जो coal face में water की छक पतली परत ना दिखने लगे
 - By water spray $\rightarrow$ CCM picks
 - Use sharp bits
 - Use correct explosive so that blasting produces less coal dust.

② During transport of coal $\rightarrow$ Tubs / mine cars $\rightarrow$ spillage

- $\rightarrow$ Haulage Track अच्छे में $\rightarrow$ Proof होने चाहिए
- बिछाना है ताकि derailment ना हो।

Belt conveyors proper aligned होने चाहिए

- $\rightarrow$ इसके नीचे coal dust collect हो गया $\rightarrow$ regular intervals में remove करें
- Water spraying
- Loading point
- Transfer point
- over belt conveyor
- chutes
- Use dust extractor
- Suction effect air tube $\rightarrow$ dust वाली हवा को $\rightarrow$ hood / canopy over loading point
- के बिना compressed Collecting vessel तक ले जाया
- air jets

③ By wetting with water or mixing with stone dust.

④ Use stone dust barriers / water barrier.

⑤ Coal cutting m/c में dust को हक जगह पर collect करने के लिए Gummer का use करते हैं।

borne Dust $\rightarrow$ size $0.1 \mu m$ & above

Inhalable dust $\rightarrow$ Dust का हक हुला सा part

$\rightarrow$ enters by nose & mouth during breathing

... kataru tracks में deposit हो जायगा

- निम्नलिखित हैं जो कि dust control में हैं।
- Water Spraying
 - Loading point
 - Transfer point
 - over belt conveyor
 - chutes
- Belt Conveyors proper aligned होने चाहिए।
 ↳ इसके नीचे coal dust collect हो जाता
 ↳ regular intervals में remove करें।
- Use dust extractor
 ↳ hood/canopy over loading point
 ↳ suction effect air tube → dust वानी हवा को के लिए compressed air jets
 Collecting Vessel तक ले जाता।
- By wetting with water or mixing with stone dust.
 - Use stone dust barriers / water barrier.
 - Coal Cutting m/c में dust को ठाम जगह पर collect करने के लिए Gummer का Use करें।

borne
 Dust → size 0.1 μm & above

Inhalable dust → Dust का ठाम छोटा सा part.
 ↳ enters by nose & mouth during breathing
 Respiratory tracts में deposit हो जाएगा

Respirable dust → Inhalable का ठाम छोटा सा हिस्सा
 ↳ यह gas exchange वाली जगह को भी cross कर जाता है।

Size range 0.1 to 10 μm .

Permissible Limit → 8 hours काम करने पर $2 mg/m^3$ से अधिक नहीं होना चाहिए।

$2 mg/m^3$ Permissible Limit given in CMR 2017 is for which type of dust?

Ans → Respirable dust.

→ $2 mg/m^3$ → if free silica % 5% से कम है।

→ free silica 5% से अधिक होने पर

↳ $10 mg/m^3$

% of free silica

यह formula आपकी अपनी mines का PL निकालने के लिए है।

→ जिस coal seam का free silica % हम ही बार determine किया जाता है या फिर coal की properties में change आता है तब करते हैं।

MINING GYAN

Reg - 143

Sub reg. 3 to 8

Dust survey → Once in a month
 ↳ कोई new equipment की installation पर
 ↳ Change in method of mining

→ Types of Dust Survey

- ↳ ① Fixed Point or static point
- ↳ ② Personal or Portal to Portal

→ Dust Sampling instruments → Dust Sampler → Maintenance

→ Results of Dust Survey → Survey करने के 14 days में
 ↳ 24 hrs के अन्दर Record करने
 ↳ Calibration shall have been done within 1 year of use

→ Actions on Results of Dust Survey (sub reg 9 to 12)

↳ अगर Result में Permissible Limit (PL) से अधिक dust पाया जाता है तो उसे कम करने का काम उठाया जाएगा

↳ Regional Inspector को inform

↳ 7 लगातार shifts में कम से कम 5 samples Collect करेंगे

↳ अगर dust का concentration PL से 1.5 times अधिक आता है तो वह काम बन्द कर देंगे

→ जहाँ पर dust को control नहीं कर सकते

- ↳ Remote operation
- ↳ Job rotation
- ↳ Dust Respirator Use करें

→ Dust Respirator को Provide करेंगे?

- ↳ Owner, Agent & Manager
- ↳ In Sufficient Number

Precautions (sub reg. 13a to 13d)

- Drilling/Cutting →
- ① Sharp bits use करें
 - ② suitable Pressure
 - ③ Clear cuttings from holes

Precautions (sub reg. 13a to 13d)

- Drilling/Cutting → ① sharp bits use करें
② suitable Pressure
③ Clear cuttings from holes
④ Jet water use करें
⑤ Dust extractor use करें
- Roadways → पानी से सीला करें
↳ Chemical shall be used with water
↳ Calcium Chloride & Magnesium Chloride
↳ यह hygroscopic nature का होता है
↳ Moisture को attract करेगा

Belowground Dust Control (Sub reg. 13e)

- ① Equipment → Dust suppressing device लगा दें
↳ lever/switch से operate होना चाहिए
- ② Mechanical Coal Cutter → water spray system
- ③ Floor/Roof/Sides/Workings/Roadway/Airway → wet by water
↳ Regular Wash
- ④ Ventilation → Air Velocity → dust को dilute करें
↳ इतना हो की dust को उठा ले ना उड़ा
- ⑤ Blasting → Blasting के पहले within 18m water sprinkling
↳ Blasting के बाद Blasted material पर पानी डालें
- ⑥ Vehicle/tubs/Conveyors → Prevent spillage
↳ water spray → chute, tippler, Loading & Discharge Point

Device → Dust Respirator

- ↳ filter
 - 7 दिन में एक बार examine करना
 - Month में एक बार testing करना है,

Dust Scheme → Manager के द्वारा बनाया जायेगा

- ↳ Regional Inspector approval होगा
- ① Location, frequency, timing & method of sampling
- ② Approved lab list
- ③ Format
- ④ Organisation
- ⑤ Training

Dust Survey Incharge → Overman's Certificate

- ↳ Min. 3 years experience (including 1 year in that mine)
- ↳ well Trained
- ↳ Trained assistants होने चाहिए

Reg. 144

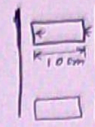
75%

85%



→ According to CIM → Polished design मा 5/न।
मा 188

- ② Strip Sampling → Treated with dust
 ↳ 10cm width
 ↳ Intervals of 5m.



- ③ Spot Sampling → Treated with water
 ↳ 1 spot of 1m length
 ↳ equal intervals
 ↳ but Zig-Zag

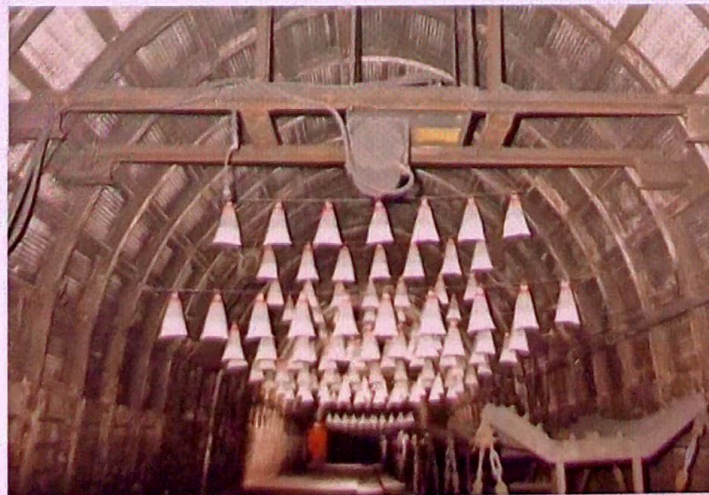
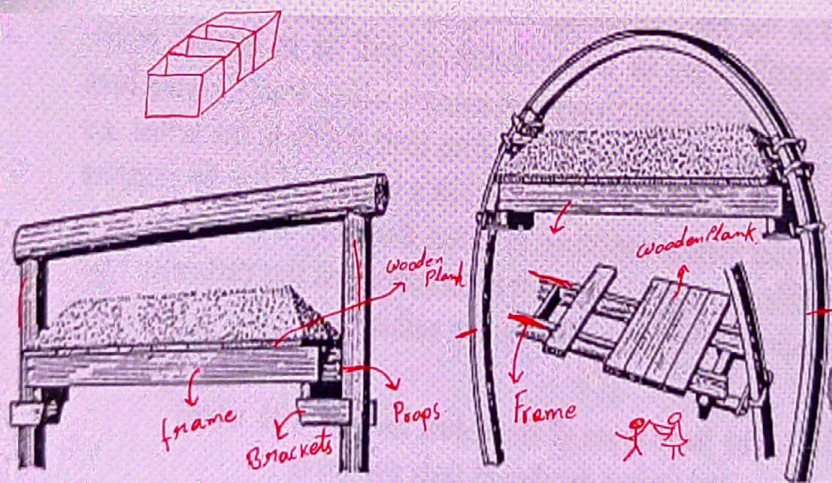


Stone dust barrier

→ According to CIM → Polished design π $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$

→ Barrier consists of

- ↳ ① Shelves side by side on Roadway
- ↳ ② Planks side by side on frame
- ↳ ③ Frame supported by props
- ↳ ④ Props erected on either side of roadway



MINING GYAN



Applications of stone dust

- Heat absorbing effect show करता है
 - ↳ Coal dust की ignition point तक पहुँचने से रोकता
- Index of explosibility of a coal dust
 - ↳ Amount of stone dust required to make coal dust non-explosive.
 - ↳ Coal dust की non-explosive बनाने के लिए stone dust की कितनी quantity में add करनी

- Index of explosibility expressed in Two ways.
 - ↳ ① by weight of stone dust added in kg/kg of coal dust.
 - ↳ ② by % of ash content in mixture after adding stone dust.

- Stone dust is of
 - ↳ shale dust
 - ↳ Limestone
 - ↳ Gypsum

- Boiler Ash is also used → इसमें siliceous matter होता है।
 - ↳ Not available in large quantity

- Mist Sprayer → Stone dust distribute करने वाला device

Types of stone dust barriers.

- ① Heavy type Barrier → 60 kg/m of shelf length
- ② Light type Barrier
- ③ Immediate Barrier

② Light type Barrier

③ Intermediate Barrier

Light type barriers $\rightarrow$ Lightly loaded shelves

$\hookrightarrow$ Dust loading $\rightarrow$ 30 kg/m of shelf length.

$\rightarrow$ Total dust in One barrier

$\hookrightarrow$ 390 kg/m² of Cross-sectional area of gallery.

Light barriers $\rightarrow$ Primary or First Barrier प्राथमिक बाधा



$\rightarrow$ Near Point of ignition ज्वलन के निकट

$\rightarrow$ width not more than 35cm.

$\rightarrow$ Distance b/w 2 shelves

$\hookrightarrow$ not less than 0.9m
not more than 2m.

$\rightarrow$ Dust loading $\rightarrow$ 30 kg/m of shelf length.

$\rightarrow$ Total dust Not less than 110 kg/m² cross-section area.

Heavy barriers $\rightarrow$ also known as secondary barriers.

$\hookrightarrow$ $\frac{2}{3}$ shelves पर load होना चाहिए

$\rightarrow$ width $\rightarrow$ not more than 50cm.

$\rightarrow$ Distance b/w shelves

$\hookrightarrow$ not less than 1.25m
not more than 2.7m.

$\rightarrow$ Dust loading $\rightarrow$ 60 kg dust /m length of shelf.

$\rightarrow$ Total dust not less than 390 kg/m² cross-section.

Intermediate barriers $\rightarrow$ अधिकांश shelves lightly loaded & अधिकांश shelves heavy loaded होना चाहिए .

$\rightarrow$ Dust loading $\rightarrow$ 135 kg/m²

Location of Barriers.

$\rightarrow$ In B & P working $\rightarrow$ Heavy type barriers use होना चाहिए

$\hookrightarrow$ nearest working face से - not less than 13.5m

$\hookrightarrow$ farthest face से - not more than 360m

→ Dust loading on shelf.

→ Total dust not less than 390 kg/m^2 cross-section

Intermediate barriers → अंतर्गत शेल्स lightly loaded & अंतर्गत शेल्स heavy loaded होंगे, $\frac{1}{2}$

→ Dust loading → 195 kg/m^2

Location of Barriers.

→ In B & P working → Heavy type barriers use होंगे
 → nearest working face से - not less than 135 m
 → farthest face से - not more than 365 m

→ In Longwall working → Light type barriers use होंगे
 face से $180 \text{ m} - 320 \text{ m}$ की distance पर
 heavy type barriers लगाएंगे।
 → gate conveyor roads की चौड़ाई से
 face से $45 - 110 \text{ m}$ की distance पर

→ Near shaft Insets → जब एक shaft से दूसरे में
 अधिक seams में काम चल रहा हो तब
 landing से 90 m की distance पर
 Heavy barriers shaft landing वाली roadway में लगाएंगे।

Maintenance of stone dust Barrier.

- ① Examination at least once in a week by Ventilation officer
- ② Dispersibility Test
- ③ Arrange for repair any damage at regular basis.
- ④ Erect New barrier Under supervision.

Information on Board Near Barrier.

- ① Cross-section of roadway.
- ② Total dust loading.

1) distance पर heavy type barriers face से 40 - 110m के भीतर लगाएंगे।

→ Near shaft Insets → लान हक shaft से डम से अधिक seams में काम चल रहा है तब
landing से 90 से 150m की distance पर Heavy barriers shaft landing वाली roadway में लगाएंगे।

Maintenance of stone dust Barrier.

- 1) Examination at least once in a week by Ventilation officer
- 2) Dispersibility Test
- 3) Arrange for repair any damage at regular basis.
- 4) Erect New barrier under supervision.

Information on Board Near Barrier.

- ① Cross-section of roadway.
- ② Total dust loading.
- ③ No. of shelves.
- ④ Date of last removal of stone dust.
- ⑤ Reference No. of Barrier.
- ⑥ Date of last Inspection
- ⑦ Signature of competent person appointed for maintenance of barrier.

Rescue Plan → Position & type of Barrier
→ Frequency & rate of its advance
Plan हर 3 month → Serial No. of barrier.
हम कर Update
करते हैं।

Telephonic Information sent by manager on explosion.

- ① Joint Director of Mines safety
- ② DGMS
- ③ Rescue station.
- ④ Police station
- ⑤ DM
- ⑥ Headquarter of Company
- ⑦ Adjacent mine
- ⑧ Hospital
- ⑨ Trade Union leaders.



MINING GYAN

Mines rescue apparatus

- Mines rescue apparatus provides protection to human breathing system against Poisonous and irrespirable gases
- Reviving apparatus
- Escape apparatus
- Self rescuers
- Gas masks
- Self contained breathing apparatus with compressed oxygen or liquid oxygen

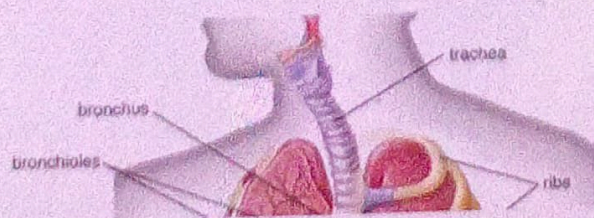
Mines Rescue Apparatus

• Poisonous and साँस नहीं लेने योग्य वाली जगह पर human को breathing system provide करके protect करता है।

- Reviving apparatus
- Escape apparatus
- Self rescuers
- Gas masks
- Self contained breathing apparatus → Compressed oxygen
→ Liquid oxygen.

Human respiration system

- Oxygen is inhaled by nose
- it reaches to nostrils
- From nostrils it goes to the windpipe or trachea
- Which divides into bronchi tubes
- Bronchi tubes are connected to alveoli sacs
- Lung is made of alveoli
- Alveoli is lined with thin capillaries having circulating blood
- Circulating blood requires continuous flow of blood
- A person inhales 21% O₂ and 79% N₂ out of which he only uses 3 to 5% of oxygen only which gets converted into CO₂ but nitrogen remains unchanged



Nitrogen - 79%
 Breathing rate → Normal work → 15 breath / minute
 → heavy work → more than 20 breath / minute

Composition of exhaled air

- Oxygen - 18 to 16%
- Carbon di oxide - 3 to 5%
- Nitrogen - 79%
- Breathing rate of person doing normal work is 15 breaths per minute
- Breathing rate of person doing heavy work is more than 20 breaths per minute
- In one breath a person consumes about 100cm^3 of oxygen which is approx. 1.5lit per minute for 15 breaths per minute

Oxygen consumed in 1 breath → about 100cm^3
 1.5 lit / minute
 for
 15 breaths / minute

Self contained breathing apparatus

- Principle of action - Consider a volume of 20lit. Of exhaled air containing 17% oxygen
- The exhaled air would comprise 3.4lit of O_2 , 15.8lit of N_2 and 0.8lit of CO_2 can be removed and an equal quantity of O_2 supplied instead to the residual air
- The resultant gaseous mixture would again have the normal composition of the atmosphere
- Self contained breathing apparatus works on this principle
- It can be used for respiration in an irrespirable atmosphere
- The wearer can move and work in an atmosphere containing poisonous and noxious gases by using it
- Its working period depends on its size but it can work from 1 hour to 4 hours

Self Contained Breathing Apparatus

Principle of action → 20 lit exhaled air of 17% Oxygen

- It can be used for respiration in an irrespirable atmosphere
- The wearer can move and work in an atmosphere containing poisonous and noxious gases by using it
- Its working period depends on its size but it can work from 1 hour to 4 hours

Self Contained Breathing Apparatus.

→ Principle of action → मान लिये कि 20 lit. exhaled air में 17% Oxygen

O_2 - 3.4 lit.

N_2 - 15.8 lit.

CO_2 - 0.8 lit.

→ Removed by
chemical absorbent.

इतनी ही quantity of O_2
SCBA के द्वारा add किया
जाता है।

• Can be used
in irrespirable
atmosphere.

• इसकी पहन कर
worker easily
move कर सकते हैं

• Working period
↓
depends on size.
↓
1 hour to 4 hours.



- Self contained breathing apparatus is closed circuit type because oxygen is supplied through the cylinder because oxygen is not lost into the atmosphere during exhalation and CO_2 is reused by him after the exhaled air freed of the CO_2 by chemical absorbents
- The unused O_2 of the exhaled breath is not sufficient for the wearer it is replenished from the cylinder containing O_2 in the compressed or liquified form
- A closed circuit type apparatus is also called regenerative apparatus
- It is of 2 types
 - Proto self contained compressed oxygen apparatus
 - Drager self contained compressed oxygen apparatus

→ SCBA → closed circuit type का apparatus

• O_2 supplied from cylinder and exhaled करने पर O_2 atmosphere में नहीं जाता है।

→ SCBA → closed circuit type का apparatus

- O_2 supplied from cylinder and exhale करने पर O_2 atmosphere में नहीं जाता है।
- CO_2 air is reused by him
→ जब chemical absorbent exhaled air को free from CO_2 बना देता है।

regenerative apparatus के नाम से भी जाना जाता है

→ Types → Proto self contained compressed oxygen apparatus
→ Dräger " " " " " "

Proto Mark 4 Apparatus

- A light alloy cylinder of 2 litre (empty) capacity, containing 300 lit. of oxygen compressed to 150 kg/cm^2 . It is fitted with main valve, a pressure gauge valve, a by-pass valve, a reducing valve. The main valve is the cylinder closing/opening valve which is kept open by a locking device when the apparatus is in use.
- The reducing valve reduces the pressure of oxygen supplied to the wearer and ensures 2 lit. of oxygen per minute.
- The by-pass valve is manually operated by the wearer if the reducing valve fails or when the wearer needs more oxygen than that supplied by the reducing valve (for example, when doing heavy work).
- The pressure gauge valve admits high pressure oxygen to the pressure gauge.
- Breathing bag made of vulcanised rubber and divided into two compartments by a partition except at the bottom end. The bag contains 2 kg of CO absorbent known as protosorb.
- It is a mixture of calcium hydroxide and caustic soda and it keeps the percentage of CO_2 in the breathing circuit below 2%.
- The wearer breathes from and into the bag which serves as an air reservoir.
- A cooling chamber of copper containing sodium phosphate which is in crystal form at ordinary temperatures but liquefies at 35°C absorbing much heat in the process.

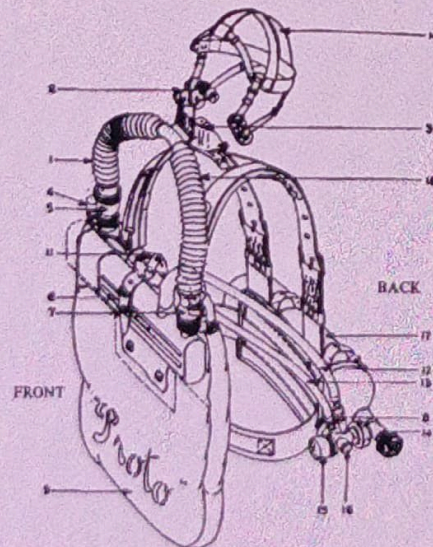


Fig 6.1. Proto mark V self contained compressed-oxygen breathing apparatus.

Proto Mark 4 Apparatus

→ Light alloy cylinder → 2 lit → 300 lit Compressed oxygen.

→ Valve → ① Main Valve → cylinder open/close करता है → by locking device.

② Pressure gauge valve
③ By pass Valve → manually operated → if reducing Valve fails

④ Reducing Valve → Reduce pressure of oxygen

- partition except at the bottom end. The bag contains 2 kg of CO₂ absorbent known as protosorb.
- It is a mixture of calcium hydroxide and caustic soda and it keeps the percentage of CO₂ in the breathing circuit below 2%.
- The wearer breathes from and into the bag which serves as an air reservoir.
- A cooling chamber of copper containing sodium phosphate which is in crystal form at ordinary temperatures but liquefies at 35°C absorbing much heat in the process.

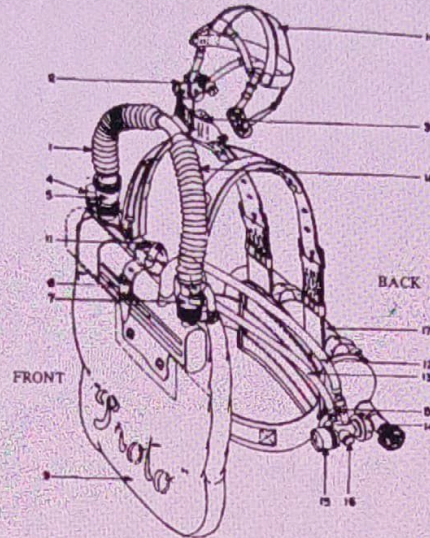


Fig. 6.1. Proto mark V self-contained compressed-oxygen breathing apparatus.

Proto Mark V Apparatus

→ Light alloy cylinder → 2 lit. → 300 lit. Compressed oxygen.

150 Kg/cm²

→ Valve → ① Main Valve → Cylinder open/close रखता है → by locking device.

② Pressure gauge valve

High Pressure O₂ का Pressure gauge में पहुँचाना

③ By pass Valve → manually operated → if reducing Valve fails

④ Reducing Valve → Reduce pressure of oxygen
2 lit. of O₂ per minute can be consumed

→ Breathing Bag → Vulcanised Rubber

→ Divided into Two Compartments

2 Kg CO₂ absorbent इसमें भरा होता है

→ Protosorb के नाम से जाना जाता है

mixture of Calcium hydroxide & Caustic soda

Circuit air में CO₂ का % 2% से कम रहना

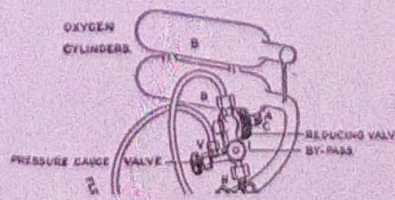
Cooling Chamber → Copper → Sodium phosphate → 35°C पर
absorbs heat from air
liquefy होता है।

Valve

→ ① Inhalation Valve

② Exhalation Valve

③ D.I. Valve



2 Kg CO_2 absorbent इसमें सटा होता है

Proto sorb के नाम से जाना जाता है
mixture of Calcium hydroxide & Caustic soda

circuit air में CO_2 का % 2% से कम रखना

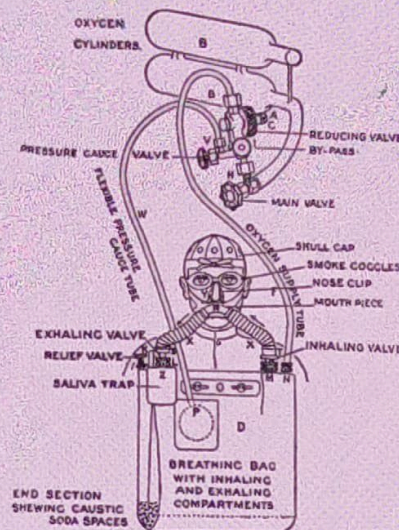
Cooling chamber $\rightarrow$ copper $\rightarrow$ Sodium phosphate $\rightarrow$ 35°C पर
absorbs heat from air
liquify होता है

Valve

- $\rightarrow$ ① Inhalation Valve
- ② Exhalation Valve
- ③ Relief Valve

Other Parts

- $\rightarrow$ Nose clip
- ① Mouth Piece
- ② Inhalation tube
- ③ Exhalation tube



- Inhalation valve, exhalation valve and relief valve. The relief valve allows the escape of any oxygen in excess of the wearer's requirement.
- Nose clip, mouthpiece, inhalation and exhalation tubes. Weight of sodium phosphate is 170g.
- The apparatus is designed for a 2-hours use.
- Breathing is through the mouth and the nasal passages are closed by a special nose clip.
- After donning the apparatus the wearer has to take a few breaths of pure oxygen and flush out the nitrogen from his respiratory system.
- In actual use the exhaled air passes over the protosorb which removes the CO_2 , on inhalation tube to the lungs.
- On exhalation the air passes through the exhalation valve to the breathing bag for further regeneration.
- The apparatus is so designed that when worn, the oxygen cylinder remains on the back and the breathing bag and cooling unit on the front of the wearer. Weight of the apparatus when fully charged is. 15.6 kg.
- Wearer of Proto apparatus Mark IV cannot speak and the communication among brigade members is by pre-decided audible signals of horns.

Proto Mark 5

- Apparatus is an improvement over Mark IV.
- It is available as a 1-hr or 2-hr apparatus.
- In 1-hr apparatus the coolant is CaCl_2 , but in 2-hr apparatus it is soda phosphate as in Mark IV
- Wt. of 1-hr apparatus is 14.5 kg. and that of 2-hr apparatus is 17.2 kg. oxygen flow rate in 2-hr apparatus is 2.0 lit/min. in 1-hr apparatus, 2.5 lit./min. 2-hr
- Mark V apparatus is fitted with a warning signal to indicate approaching cylinder exhalation, and it can be supplied with a wide vision face piece (Vistaram mask) and a speaking diaphragm.
- The by pass valve is of push button type instead of the hand- wheel type of Mark IV.
- Excepting the differences stated above between the Mark IV and Mark V apparatus, the specifications of Mark V are the same as those of Mark IV.
- Latest apparatus in the market is Mark IV model 80 which is practically like Mark IV. the spare parts of both being interchangeable.

MINING GYAN

Drager SCBA (Model BG174)

- Like the Proto apparatus the Drager apparatus is also compressed oxygen type, with closed circuit for the inhaled and exhaled air, rendering the wearer self dependent in an atmosphere of toxic and poisonous gases, whatever their percentage.
- Compared to Proto apparatus of 2-hr duration the Drager apparatus (model BG 174) is light, weighing only 12.8 kg when fully charged with compressed air, and it has duration of 4 hrs.
- The compressed O₂ is held in an alloy cylinder at 200 kg/cm².
- Capacity of the oxygen cylinder is 2 litres and the oxygen available is 400 litres.
- Capacity of the breathing bag is approximately 6 litres.
- The constant feed rate from the apparatus is 1.5 l.it/min. and a lung-governed valve automatically adjusts the oxygen feed to the wearer's requirement over and above the 1.5 lit/min.
- The apparatus is therefore completely automatic and the breathing air is controlled by the respiratory valves.
- The exhaled air is regenerated by absorption of CO₂, as it passes over an air cooled regenerating alkali cartridge.

Specification of BG174

- Safe working period 4 hr hard work
- empty Cylinder capacity with O₂ at 200 kg cm² two lit 400 lit
- Breathing big capacity, approx. Wt. of apparatus, fully charged 6 lit Oxygen flow rate 12.8 kg. 1.5 lit/min Oxygen feed by lung governed valve as required by wearer

Drager SCBA

- Oxygen Compressed type होता है।
- Closed Circuit → exhaled air
↓
Inhaled air
- Light weight → 12.8 Kg → when fully charged
- Duration 4 hrs.
- Compressed O₂ → 200 Kg/cm²
- Capacity - 2 lit → oxygen available → 400 lit.
- Breathing bag Capacity → 6 lit.
- Feed rate → 1.5 lit/min
- CO₂ जो air को cooled regenerating alkali cartridge से pass होता है ता उसका absorption होता है।

Special features

Special features

- ① Cylinder Valve open करने पर breathing bag में 7 lit. O_2 भर जाता है
 ↳ इससे N_2 निकालने की जरूरत नहीं पड़ती।
- ② Inhalation Valve के नीचे inhalation passage में warning device fit रहता है।
 ↳ lung demand valve से इसे control किया जाता है।

Dräger



- lung demand valve automatically operate होता है & manually operate करने के लिए by pass valve से कर सकते हैं।
- Training purpose के लिए rechargeable soda lime Cartridge.
- Pressure reducer → सही working pressure provide करना
- face mask → To provide wide Vision
- Automatic relief Valve → Circuit में ज्यादा pressure होने पर extra oxygen remove करता है।

Special features of BG174

- On opening of valve breathing bag automatically gets filled with 7lit. Of oxygen so it is not needed to remove nitrogen from the bag
- A warning whistle is fitted in the inhalation passage below the inhalation valve. It gives warning about the empty cylinder or if cylinder valve is closed while using
- Lung demand valve operates automatically to provide oxygen but it is limited to 1.5lit./min. A manually operated by pass valve is provided admit more oxygen to the circuit
- A rechargeable soda lime cartridge can be used for training purpose
- Pressure reducer reduces oxygen pressure upto a tolerable working pressure of 4kg/cm
- The breathing bag is protected from heat

- 12:16 0.02 KB/s 5G 74
- face mask → To provide wide vision
 - Automatic relief valve → Circuit में ज्यादा pressure होने पर extra oxygen remove करता है।

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- Pressure reducer reduces oxygen pressure upto a tolerable working pressure of 4kg/cm
- The breathing bag is protected from all sides
- A face mask for wide vision can be used instead of gas light protective goggles with triplex safety glasses
- Automatic relief valve eliminates excess pressure of circuit in case of low oxygen consumption

AUER/SAR - 30

- It is a chemical oxygen breathing apparatus for work and rescue
- It is manufactured by AUER in west Germany
- It protects the user from toxic and oxygen deficient atmospheres for approx. 30 minutes
- It can be used at confined places like
 - Shafts
 - Manholes
 - Small confined areas
 - Sewerage systems
- It consists of full face mask with speech diaphragm, the breathing hose, the breathing bag with vent vane, the KO₂ canister with quick start system

AUER/SAR - 30

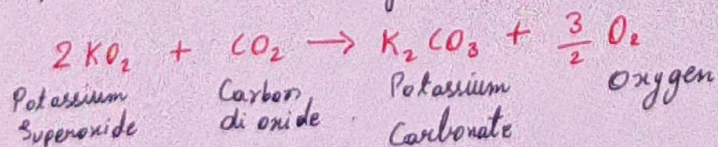
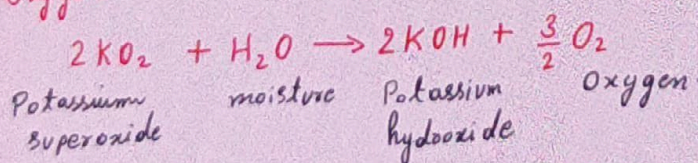
- Chemical oxygen type breathing apparatus → rescue work.
- AUER manufacturer → West Germany.
- 30 minutes तक toxic atmosphere में protection provide करता है।
- It can be used at confined places
 - ↳ Shafts
 - ↳ Manholes
 - ↳ Small confined Places
 - ↳ sewerage system
- Parts → ① full face mask
- ② speech diaphragm
- ③ Breathing hose

- It consists of full face mask with speech diaphragm, the breathing hose, the breathing bag with vent valve, the KO₂ canister with quick start system

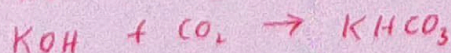
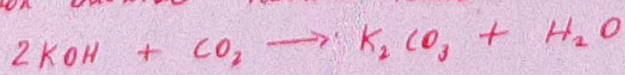
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 - ↳ sewerage system.
- Parts →
 - ① full face mask
 - ② speech diaphragm
 - ③ Breathing hose
 - ④ Breathing bag → Vent Valve
 - ⑤ KO₂ canister → with quick start system
- KO₂ canister → Potassium Superoxide → breathing & ऑक्सीजन provide करता है।
- when KO₂ reacts with moisture ऑक्सीजन produce होता है।
- second reaction → b/w potassium hydroxide & CO₂

Oxygen Generator Reaction



Carbon dioxide Remover Reaction



Carbon dioxide Remover Reaction



- यह device demand sensitive है → CO_2 & humidity की quantity के हिसाब से operate करता है।
 → जितना ज्यादा hard work करेगा उतना ही O_2 भी produce होगा होता है।
 → KO_2 consumption से अधिक oxygen बनाता है
 → extra O_2 breathing bag में store हो जाता है।

- The oxygen needed for breathing is produced by potassium superoxide contained in the canister
- Oxygen is liberated by the chemical reaction of moisture with the KO_2
- A second reaction takes place between potassium hydroxide which is the product of the potassium superoxide and water and the CO_2 of the exhaled breath to combine and retain CO_2
- They respond to the quantity of CO_2 or humidity available and thus make the device demand sensitive
- The harder the user works, the more oxygen is generated and the more CO_2 is removed
- The KO_2 liberates oxygen at a rate slightly faster than it can be consumed by the wearer thus adequate oxygen supply regardless of work rate is ensured
- The oxygen produced by the chemical is inhaled through the breathing bag which also serves as breathing air reservoir
- The quick start system covers the immediate oxygen requirements of the user until the chemical of the canister becomes activated by the exhaled air
- Donning the face mask activities automatically the warning signal system which releases after approx. 20min a visual and audible retreat warning signal
- This signal lasts for approx. 10min and reminds the wearer to leave the contaminated area
- The chemical canister is easy to exchange without special tools
- The canister cover serves as carrying appliance, heat insulating cover and shock protector
- Arranged between breathing bag and breathing tube is the heat exchanger which cools the air heated up by the chemical reaction
- Operating life – approx. 30min
- Shelf life – upto 5 years if stored properly

→ Quick start system → इसका इस oxygen की जरूरत पड़ने पर chemical reaction oxygen provide करता है।

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→ Quick start system → इसका इस oxygen की जरूरत पड़ने पर chemical reaction start होने के पड़ने oxygen provide करना

→ Warning system → face mask लगाने पर activate हो जाता है and 20 minute बाद 10min के continuous warning देगा to leave the contaminated area

→ Operating life → 30min shelf life → upto 5 years

MINING GYAN

SCBA – Model Spiral 2C

- It is also a closed circuit breathing apparatus using potassium superoxide (KO_2)
- The apparatus consists of 6 main parts
 - Mouth piece and nose clip
 - A corrugated hose connecting the mouth piece to the breathing bag
 - A breathing bag made of special fabric coated polyurethane, with pressure relief valve and directional valve
 - The KO_2 canister with its starter assembly which gives oxygen immediately
 - A plastic carrying case
 - A harness system (Neck strap and belt)

SCBA → Model → Spiral 2C

- Closed circuit breathing apparatus
- Potassium superoxide is used
↳ KO_2
- 6 main parts →
 - ① Mouth piece & nose clip
 - ② Hose pipe → To connect mouth piece and breathing bag
 - ③ Breathing bag → special fabric से बना होता है and polyurethane की coating होता है
 - ④ KO_2 canister
 - ⑤ Plastic carrying case
- ⑥ harness system

Working of Model Spiral 2C

- **Operation:-** Suspend it round your neck, pull the red lever and take the cover away from the case. Then put the mouthpiece into your mouth, place the nose clip and pull the red plate of the starting system in front of you.
- **Breathing circuit:-** The exhaled gases go by the corrugated tube through the KO_2 canister to be stored, regenerated, in the breathing bag (4) When inhaling, the gases stored in the breathing bag go to the directional valves by the corrugated tube to reach the mouthpiece
- **Technical data:-** Weight in its carrying case: 3.3 kg in use: 3 kg; Dimensions - breadth : 190 mm, height: 290 mm, depth: 120 mm; Duration-1 hour to 4 hours (depending on the work performed);
- **Breathing resistance:-** when exhaling: 20 to 50 mm column of water at the end of operation, when inhaling: 5 mm column of water
- **Starting of apparatus:-** Automatic by pulling the red plate; concentration of CO_2 constantly remains below 1% temperatures of the gases constantly remains below $30^\circ C$, even at the end of operation; KO_2 Canister (interchangeable) - 900g with incorporated starter assembly.

Working of Spiral 2C

- ① Operation → Pull red lever, neck के चारों तरफ लगाने के बाद
mouth में डाला जाता है and

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Working of Spiral 2C

- 1) Operation $\rightarrow$ Pull red lever, neck के चारों तरफ लगाने के बाद
 $\rightarrow$ mouthpiece को mouth में डाला जाता है and nose clip से nose बंद करते हैं।
- 2) Breathing Circuit $\rightarrow$ KO_2 exhaled air को regenerate करके breathing bag में store करता है।
 $\rightarrow$ Breathing bag से O_2 को inhale किया जाता है।
- 3) Technical data $\rightarrow$ weight $\rightarrow$ 3 Kg.
 $\rightarrow$ Dimensions $\rightarrow$ breadth $\rightarrow$ 190mm
 $\rightarrow$ height $\rightarrow$ 290mm
 $\rightarrow$ depth $\rightarrow$ 120mm
 $\rightarrow$ Duration $\rightarrow$ 1 hour - 4 hours.
- 4) Breathing Resistance $\rightarrow$ when exhaling $\rightarrow$ 20 to 50 mm ^{column} of water
 $\rightarrow$ When Inhaling $\rightarrow$ 5mm column of water
- 5) Starting of apparatus $\rightarrow$ By pulling Red lever
 $\rightarrow$ % of CO_2 $\rightarrow$ always remains less than 1% at 30°C

Gas Mask

- In gas masks, self rescuers and some other rescue apparatus the chemical hopcalite consisting of a mixture of manganese dioxide and copper oxide is used as a catalyst which changes CO to CO_2
- The conversion is an exothermic action by the generation of heat
- This is an apparatus used by the wearer to protect himself from the poisonous atmosphere containing mainly CO and also the toxic gases in small percentages
- Atmosphere should contain sufficient oxygen to support life and should not contain more than 2% of CO

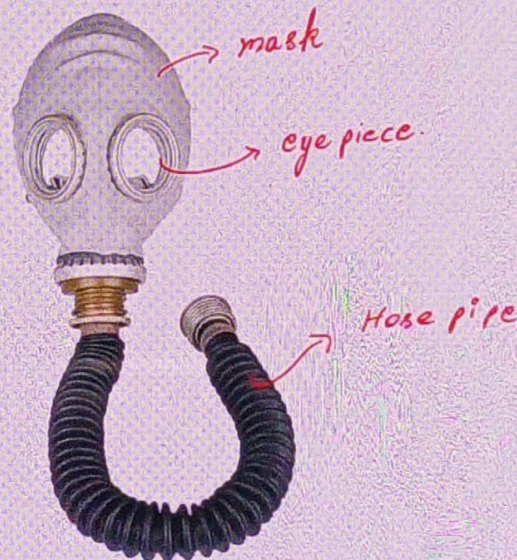
Gas Mask

- $\rightarrow$ chemical $\rightarrow$ hopcalite and manganese dioxide and copper oxide के mixture का use होता है।
1. 1. 1. copper oxide $\rightarrow$ यह as a.

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Gas Mask

- chemical → hopcalite and manganese dioxide and copper oxide $\frac{1}{2}$ mixture का use होता है।
- Manganese dioxide & copper oxide → यह as a Catalyst होता है।
- Exothermic reaction CO converted into CO_2
 ↳ जिसमें heat produce होता है।
- Limitation → Atmosphere में life support करने लायक Oxygen होता चाहिए and 2% से कम CO होता चाहिए



Gas mask consists of

- Anhydrous calcium chloride as a drier to remove water vapour. This is usually the top most layer



Gas mask consists of

- Anhydrous calcium chloride as a drier to remove water vapour. This is usually the top most layer
- Hopcalite – It acts as a catalyst which changes CO to CO₂. It also absorbs organic vapours
- Cotton wool to remove dust and smoke
- Silica gel to remove ammonia and water vapour
- Caustic soda to remove sulphuretted hydrogen
- Impregnated activated charcoal to remove organic vapours and the acidic gases. This is the bottom most layer

Gas mask consists of

- 1) Drier → To remove water vapour → Top most layer
↳ Anhydrous Calcium Chloride
- 2) Hopcalite → It acts as a catalyst
↳ Converts CO to CO₂
↳ absorbs organic vapours.
- 3) Cotton wool → To remove dust & smoke
- 4) Silica gel → To remove ammonia and water vapour
- 5) Caustic soda → To remove sulphuretted hydrogen.
- 6) Charcoal → To remove acidic gases
↳ bottom most layer

→ Metal canister → Inlet Valve fit रस्ता है
→ air inhale करने पर air सभी layers से पास होता है।

→ face piece / face mask → eye piece

→ Exhalation Valve → Connected to canister by hose pipe

→ weight → 4 kg.

→ Shelf life of sealed canister → 2 to 4 years.

- The metal canister is fitted with an inlet valve and the atmospheric air while inhaled passes through an opening at the bottom of the canister through different layers
- The air must be well dried before it comes into contact with the hopcalite so that it is not affected by moisture and remains in granular form.
- Hopcalite ceases to be an effective catalyst when it becomes powder or undergoes hydration

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- Hopcalite ceases to be an effective catalyst when it becomes powder or undergoes hydration
- A face piece fitted with eyepiece and an exhalation valve and connected to the canister by a corrugated hose pipe
- Wide vision face mask is also available in place of the facepiece with twin eyepieces
- A gas mask weighs only 4kg and it can be easily worn by an untrained person after a few minutes of instruction
- The wearer is free to use his both hands and his movements are not obstructed by the size and shape of the apparatus
- Sealed canisters have a shelf life of 2 to 4 years but canister should be discarded within one year after the seal is broken
- A wearer can use a canister for a service period of nearly 1 to 2 hours in an irrespirable atmosphere

Self rescuer

- A self rescuer is essentially a gas mask in a simplified form without the corrugated hose tubing and the mouthpiece is attached directly to the canister.
- Its weight is low, nearly 1 kg.
- The chemicals are the same as those used in the gas mask and the wearer is protected against CO if it does not exceed 2% by volume in the air to be inhaled, if the oxygen is sufficient to support life and if the air does not contain other toxic gases and vapour. The self rescuer does not supply oxygen but functions to convert carbon monoxide, a highly toxic gas, into carbon dioxide, a non toxic gas.
- The main purpose of a self rescuer is to enable the wearer to escape through an atmosphere resulting after a fire or after an explosion in a mine.
- The self rescuers are stored on the surface in the lamp room or in a self rescuer room adjacent to the lamp room thereby enabling the worker to pick up his lamp and the self rescuer at the same time when going down the mine.
- A self rescuer should be used immediately at the first sign of fire or explosion-even if no smoke is visible.
- Waiting until smoke is visible may prove fatal because the area could be filled with a poisonous concentrated odourless, colourless CO in advance of the smoke.

Self Rescuer

- Gas mask का simplified version.
- hose pipe
- mouth piece
- canister.

- Weight → 1kg.
- Gas mask जहाँ chemicals से use होता है,
- Limitation → 2%. से अधिक CO नहीं होता चाहिए
→ पर्याप्त O_2 होता पाठिका to support life.

rescuer at the same time when going down the mine.

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Self Rescuer

→ Gas mask का simplified version

↓
hose pipe
canister.
↓
mouthpiece

→ Weight → 1 Kg.

→ Gas mask जहाँ chemicals से use होता है।

→ Limitation → 2% से अधिक CO नहीं होता पाइया
→ पर्याप्त O_2 होता पाइया to support life.

→ Highly toxic gas CO को less toxic gas CO_2 में convert करता है।

→ Main purpose of self rescuer → wearer को toxic atmosphere से बाहर निकाल कर ले जाना
↓
after fire/explosion

→ Self rescuer surface पर lamp room/separate room besides lamp room में store किया जाता है।
→ worker 1/4 में जहाँ समय आने साग इस लेकर जाइगा



* The miner should therefore wear the rescuer immediately on seeing any one of the following signs:-

* Clouds of smoke, smell of combustion gases, headache and giddiness, unexpected dust eddies, sudden pressure surge.

* The drying agent is charcoal impregnated with a mixture of calcium bromide and lithium chloride (approx. 52% CaBr₂ and 5% LiCl).

- The miner should therefore wear the rescuer immediately on seeing any one of the following signs:-
 - Clouds of smoke, smell of combustion gases, headache and giddiness, unexpected dust eddies, sudden pressure surge.
- The drying agent is charcoal impregnated with a mixture of calcium bromide and lithium chloride (approx. 53 % CaBr, and 5% LiCl).
- The CO catalyst is hopcalite, as stated earlier, effects the conversion of CO to CO₂ which is accompanied by generation of heat of reaction.
- The filter section has an outer coarse-dust filter and an inner fine-dust filter to remove dust particles.
- The filter materials are separated by screens and baffles.
- The self rescuer can be used for one hour after its seal is broken in atmosphere of 1% CO and the actual filter canister has to be replaced before re-use, but the manufacturers recommend that the self rescuer should be discarded after one use only.

→ minor self rescuer को पहनने पर ध्यान देना

- ↳ ① Clouds of smoke
 ② Smell of combustion gases.
 ③ headache
 ④ Unexpected dust generation.
 ⑤ Sudden change in pressure gauge.

→ Drying agent → Calcium bromide & lithium chloride
 mixture charcoal के साथ बनाया जाता है।

→ CO catalyst → hopcalite.

→ Filter → Coarse-dust filter
 ↳ To remove dust particles.

→ self rescuer की seal break करने के बाद 1% CO वाली atmosphere में 1 hour तक इसी use कर सकते हैं।

↳ Re use करने filter replace करना पड़ेगा

Drager self rescuer

- A self rescuer model 810 is manufactured by the firm of Drager.
- The container is closed by negative pressure (vacuum sealed)
- The difference between the normal external pressure produced on closing,

Drager self rescuer

- A self rescuer model 810 is manufactured by the firm of Drager.
- The container is closed by negative pressure (vacuum sealed)
- The difference between the normal external pressure produced on closing, forms the locking force (about 70 kg), which is impervious to water vapour.
- Weight of the self rescuer is nearly 1 kg and height 135mm. It gives protection for atleast 1½ hours in atmosphere containing 1% CO.
- In an emergency the opening lever is lifted, producing an aperture at a predetermined breaking point in the cover.
- The pressure of the atmosphere and the interior of the container is immediately balanced. The cover can now be removed easily.
- The self rescuer is taken out and put on.
- After the self rescuer is donned the breathing is by mouth and not by nose which is closed by noseclip

Drager self rescuer

→ Container vacuum sealed होता है।
↳ -ve pressure.

हस्तांतरण करण 70 Kg का locking force develop होता है।

→ Weight → 1kg, height → 135mm

→ Service hours → 1½ hours in atmosphere containing 1% CO

→ Emergency के case में opening lever को lift करने पर cover में breaking point develop होता है।

→ यह सिर्फ escape purpose के लिए है।

- The importance of training the user prior to an emergency in the use of the noseclip and of breathing through the self rescuer at all times until fresh air is reached, is emphasised by the fact that CO concentration of 0.5% (5000ppm) can cause rapid collapse, unconsciousness, and death within a few minutes.
- It is far better to be alive with a hot or even blistered mouth than to be overcome or killed by CO.
- Do not sneak a breath or two of relatively cool air into the mouth by opening the lips. After putting on the self rescuer the worker should hurry up to reach the safe atmosphere
- The more quickly one runs, the higher is the breathing resistance. If exhausted, he should pause, for a moment.
- After putting on the self rescuer, the worker should not speak when in an irrespirable zone but communicate by signs and nods
- A filter self rescuer is only an escape until and should in no case be used for reconnaissance or as a working unit, or for fire fighting

→ It can't be used as → ① Reconnaissance Unit
② Working Unit
③ fire fighting

Air pressure hose apparatus

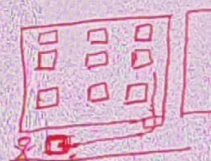
- There are two types of rescue apparatus for use at a place of irrespirable air which is not far from an area of fresh air, upto about 50 m They are
 - Smoke helmet
 - Hose mask
- Both these apparatuses require the wearer to depend upon other man for supply of fresh air when the wearer himself is working in an irrespirable atmosphere.
- The smoke helmet is a helmet made of tough polyethene having mica eye pieces fitted in aluminium frame.
- It is provided with canvas strapping to cover the shoulder.
- The helmet totally covers the face and head of the wearer and is provided with a flexible hose pipe of 25 mm bore, 30m long.
- The wearer receives supply of fresh air through the hose pipe from a hand-driven bellows in fresh air operated by a second person.
- The bellows is operated sufficiently fast to supply requirement of air of the wearer.
- The exhaled air passes from the helmet via the loose joints of canvas strappings around the shoulders of the wearer.

Air Pressure hose pipe Apparatus

→ irrespirable atmosphere - fresh air वाली area से करीब 50 approx 50m तक इसे use करते हैं

① Smoke helmet } wearer fresh air के लिए किसी दूसरे व्यक्ति पर निर्भर रहता है।
② Hose mask }

→ smoke helmet → Aluminium frame
↳ Canvas strap → to cover shoulder
↳ Mica eye piece
Hose pipe
↳ dia - 25 mm
↳ length → 30m

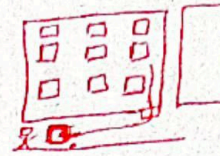


Hose mask

- It has unidirectional separate inhalation and exhalation valves
- An air filter to prevent entry of dust and foreign matter
- A corrugated tube between the mask and the air tube of rubber (30-100m).
- The mask permits more freedom of movement to the wearer's head as compared to the smoke helmet

- (1) Smoke helmet } wearer fresh air के
 (2) Hose mask } लिठा किसी ट्यूब से जोड़कर
 पर लिटर रहता है।

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- An air filter to prevent entry of dust and foreign matter
- A corrugated tube between the mask and the air tube of rubber (30-100m).
- The mask permits more freedom of movement to the wearer's head as compared to the smoke helmet.
- The corrugated hose pipe connected to the mask forms an air reservoir or "equaliser".
- In both the above apparatus the air hose pipe is under a continuous positive pressure and there is no danger to the wearer from the leakage of outside irrespirable atmosphere into the apparatus.
- The maximum length of air hose to be used with pressure hose apparatus is 50 m if manual bellow is used.
- When using air from a compressed air supply pipe line, an oil filter should be used for cleaning the air.
- At the place from where fresh air is supplied by the bellow to the wearer a lighted flame safety lamp and a canary should always be kept for indications of oxygen shortage, carbon monoxide and methane.

Hose Mask

- Inhalation & Exhalation Valve separate होता है।
 → Air filter लगा होता है।
 → Rubber की air tube (30-100 m long)

→ length of hose pipe → not more than 50 m
 (in case of manual bellow)

→ If compressed air is being provided → oil filter
 का use करेंगे for
 cleaning air.

MINING GYAN

Reviving apparatus

- A reviving apparatus is used to administer pure oxygen
- To an unconscious person
- To one whose breathing is considerably feeble for some other cause
- Accidental burial under a heap of landsliding earth or other material, drowning choking, traffic accidents, collapse these are other occasions demanding use of reviving apparatus.
- The apparatus is sometimes used in conjunction with some other method of artificial respiration and is then brought into operation after the patient's breathing is rapidly restored.
- In an emergency, a victim who is being carried from inbye irrespirable atmosphere of a mine to a fresh air base, can be given treatment from a reviving apparatus by the rescue team on the way as the team is still on the move.
- The treatment has, however, to be given when the patient and rescue team are passing through a zone free noxious gases or at the fresh at the fresh air base.
 - Two cylinders, each containing 400 lit. of oxygen charged to 120 atmospheres.
 - Reducing valve
 - Hand-control valve
 - Dial calibrated from zero to 30 litres per min
 - Flexible breathing bag,
 - Corrugated tube, with inhalation valve, leading to a face mask fitted with exhalation valve, and also an inlet valve opening to the other atmosphere.
 - Pressure gauge and main valve

Reviving Apparatus.

→ Oxygen देने के लिए use किया जाने वाला apparatus

① To Unconscious person,

② Person having feeble breathing
(हीमा)

→ किसी भी हेर के नीचे दब जाना, डूबना, टकराना
इस कारणों से व्यक्ति बर्हीश हो सकता है।

→ Emergency के case में victim को irrespirable area
से fresh air base तक ले जाते समय इसकी
help से treatment दे सकते हैं।

- The complete apparatus weighs 16 kg.
- A somewhat lighter single-cylinder model is also available
- While using the apparatus, hand control valve opens on opening of the main valves.
- Hand control valve will prevent the collapsing of the breathing bag
- The rate of flow usually ranging from 10 to 30 litres per min.
- According to the rate and depth of the patient's breathing. The quantity of oxygen breathed (within the controlled limits) thus depends on the patient himself.
- If the patient requires more than 30 litres per min., he draws additional air through the inlet valve on the mask.
- Because of its size and weight the rescue team can carry only one apparatus inbye the fresh air base, in addition to the other equipment which the team has to carry

→ अगर किसी व्यक्ति को 30 Lt/min से अधिक O_2 की जरूरत है
तो वह mask के inlet valve से fresh air ले सकता है।

① Reducing Valve

③ Hand Control Valve

④ Dial

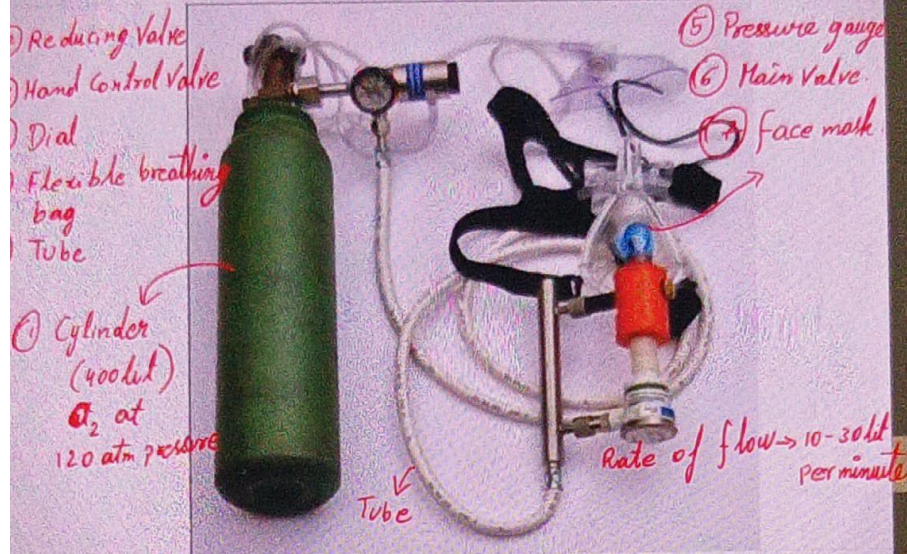
⑤ Flexible breathing



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अगर किसी व्यक्ति को 30 लिटर/मिन से अधिक O_2 की जरूरत है तो वह mask से inlet valve से fresh air ले सकता है।



- 1) Which apparatus is used for providing Oxygen to Unconscious Person?

Ans → Reviving apparatus, pulmotor, Maxometer

- 2) What is provided by Reviving apparatus?

Ans → Oxygen

- 3) Reviving apparatus is also known as _____

Ans → Resuscitating apparatus, Resuscitator

- 4) What is used to provide O_2 at a rate more than 30lit per minute to an unconscious person.

Ans → Inlet Valve on the mask.

Pulmotor

- It is a reviving apparatus of drager
- It is used to give effective, immediate assistance in case of gas poisoning and where breathing has stopped temporarily or become feeble in situations stated earlier.
- The Pulmotor switching unit to which a face mask of suitable size is attached is hose-connected to the Pulmotor distributor manifold and fed with oxygen from the cylinder.
- A cylinder is of 2.5 litre capacity holding oxygen under a pressure of 200 bars, i.e., 500 litres of oxygen at atmospheric pressure.
- The changeover valve of the Pulmotor is normally set to 50 % O_2 , the balance bring fresh air entertained by an injector.
- The device can be changed over to 100 % O_2 in gas contaminated atmosphere.
- Provided that the respiratory tracts are clear and the mask fits tightly, the respiratory air flows into the lungs of the victim and produces a clearly visible expansion of the thorax.

Pulmotor

- It is a reviving apparatus
- Gas poisoning होने पर व्यक्ति को effective तरीके से तुरंत O_2 provide करने के लिए use करते हैं।

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- Conditions for using Pulmotor →
 - ① Gas Poisoning
 - ② Breathing stopped temporarily.
 - ③ Breathing is feeble.
- Cylinder → 2.5 lit Capacity
 ↳ To hold oxygen under pressure of 200 bars
- It can supply 100% Oxygen in gas contaminated atmosphere. 500 lit. at atmospheric pressure.



Cylinder

- It is automatic also sucks air from lungs
- at +20 mbar
 ↳ Inhalation phase complete होता है और lungs में air suck करने लगता है।



- at -10 mbar
 ↳ exhalation phase complete होता है and inhalation start होता है।
- Switching rate depends on
 - ① Size of lungs
 - ② Oxygen inflow

- As soon as a pressure of about +20 mbar is reached in the lungs, and the inspiratory phase is thus completed, the appliance switches over automatically to expiration and begins to suck the air out of the lungs.
- Then when the required negative switch-over pressure of 10 mbar is reached, towards the end of the expiratory phase, a new inspiratory phase begins.
- The switching rate depends on the size of the lungs and on the oxygen inflow. If switching is too fast, the oxygen supply must be reduced at the distributor control valve and increased if switching is too slow.

phase begins.

- The switching rate depends on the size of the lungs and on the oxygen inflow. If switching is too fast, the oxygen supply must be reduced at the distributor control valve and increased if switching is too slow.
- The negative pressure at the end of expiration helps especially to assist the circulation; but in special cases (e.g. corrosive gas poisoning) pressurised respiration only can be advisable.
- A Dräger special attachment, supplied for this purpose, is the respiratory valve for cutting out the negative phase, inserted between the Pulmotor switching unit and the face mask to ensure that negative pressure is not produced during the expiratory phase.
- Expiration takes place spontaneously through the collapse of the expanded thorax.

The Pulmotor switching unit indicates faults in use automatically:-

- Unless the mask fits tightly the pressure required for switching over cannot build up and the Pulmotor switching unit remains inoperative. In such cases it is usually sufficient to press the mask more firmly against the face to prevent the respiratory air escaping.
- If the respiratory tracts are blocked, this is indicated by very rapid switching ("chattering"). Lifting the lower jaw and extending the neck is often sufficient to clear the respiratory tract; but if the respiratory tracts are blocked by secretions, water or blood, then removal by suction is necessary.
- This ability of the switching unit to indicate whether or not the lungs are being supplied with adequate respiratory air is exclusive to the Pulmotor.
- Blocked respiratory tracts frustrate any attempt at ventilation of the lungs.
- Pulmotors are equipped with oxygen powered injectors.
- Their powerful suction removes mucus, water and blood from the respiratory tract in seconds.
- The extracted secretions are collected in a receptacle and respiration can then begin or be continued forthwith.
- The breathing bag in which inflowing O₂ accumulates during the expiratory phase helps to conserve oxygen.
- Its movement enables the breathing to be observed and the necessity of ventilation of lungs to be determined.

→ Expiratory phase में -ve pressure की शीकनी के बिना Pulmotor switching Unit and face mask के बीच में Respiratory Valve fit किया जाता है।

→ Pulmotor Switching Unit indicates fault

① जब तक mask tightly fit नहीं होता है तब तक यह काम नहीं करेगा

② अगर साँस लेने वाले parts (Respiratory Tracts) block हैं तो जल्दी-जल्दी switching करना लगना है।

→ Clearing Respiratory Tract

- (→ ① Lift lower jaw (निचली जबड़े को हल्का ऊपर उठाना)
② extending the neck.

if blocked due to secretions, blood, water clearing will be done by suction.

→ Pulmotor में oxygen powered injectors लगते होते हैं,
↓
Powerful suction करके mucus, water & blood को remove करता है।

MINING GYAN

Resuscitation

- It is the process of inducing artificial respiration in a person who is unconscious and whose rate of breathing has become considerably feeble.
- Such occasions may arise if a person has received electric shock or has inhaled oxygen-deficient air or toxic gases.
- When the breathing is too feeble the lungs are not ventilated with adequate quantity of air or oxygen which the patient needs and he may die in course of time, sometimes within a few minutes.
- The resuscitation operation must be continued once it is started till natural breathing is restored or till it is considered that it will be of no avail.
- The processes of manual artificial respiration, commonly used, are:-
 - The Schafer's method
 - Sylvester's method
 - Mouth to mouth resuscitation.

Resuscitation → पुनर्जीवन

- Artificial respiration दिया जाता है
 - To Unconscious person
 - To person having feeble breathe
- Resuscitation operation तब तक करते हैं जब तक की व्यक्ति naturally breathing ना करने लगे
- Types of Manual artificial Respiration
 - ① Schafer's method
 - ② Sylvesters method
 - ③ Mouth to mouth respiration method

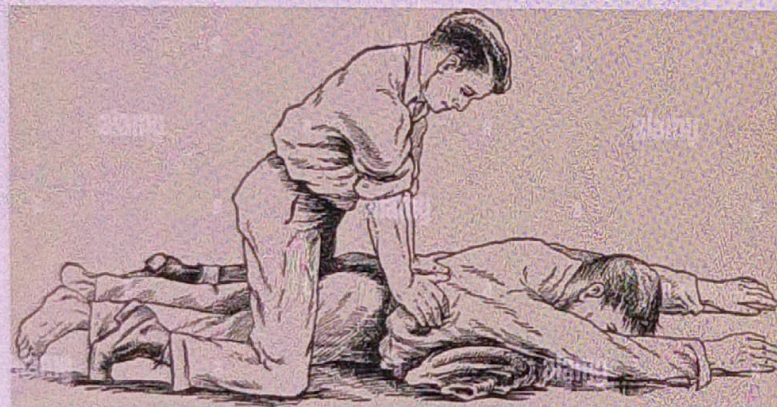


Schafer's method

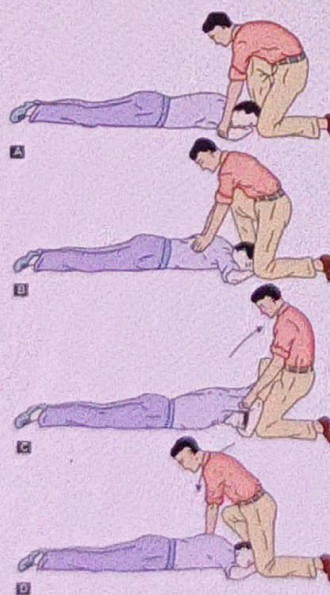
- Adjust the patient's in a prone position (i.e. back upwards with arms extended above the head, and his head turned to one side, so as to keep his nose, and mouth away from the ground.
- Do not waste time loosening clothing; no pad is to be placed under the patient, nor need the tongue be drawn out, as it will fall naturally towards

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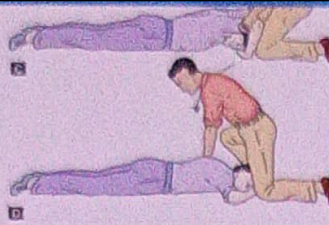
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- Do not waste time loosening clothing; no pad is to be placed under the patient, nor need the tongue be drawn out, as it will fall naturally towards the lips.
- To turn the patient to the prone position, stoop at his side, place his arms close to the body, cross his far leg over his near leg and, protecting his face with one hand, with the other, grasp the clothing at the hip on the opposite side of the body and pull smartly over.
- Imitate the movements of breathing.
- Induce expiration: Kneel at one side of the patient, or keep his thighs between your thighs, facing his head and sitting on your heels.
- Place the palms of your hand on the patient's loins, their lower edges just clearing the top of the pelvis, the wrists nearly touching, the thumbs as near each other as possible without strain and the fingers passing over the loins



Holger Nielsen Method



- On either side and pointing towards the ground, but not spread out, bending your body from the knees and somewhat straightening the hip-joints swing slowly forward keeping your arms quit straight and rigid so that the weight of your body is conveyed to your hands directly downwards.
- No exertion is required; the necessary pressure is imparted by the weight of your body.
- In this way the patient's abdomen is pressed against the ground; the abdominal



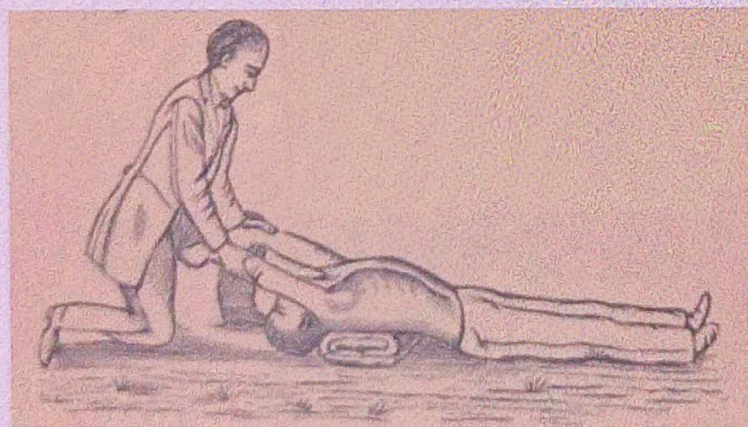
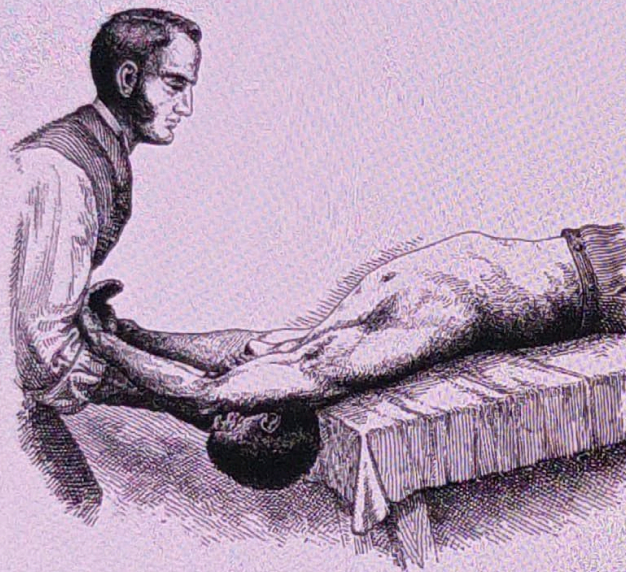
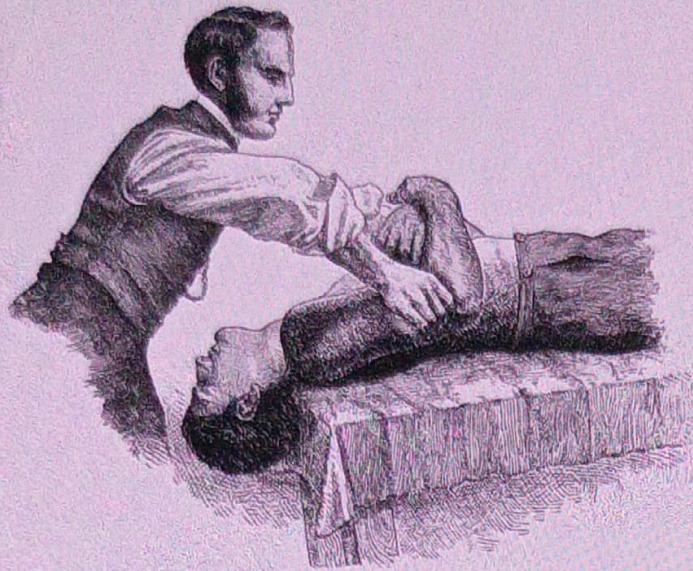
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- No exertion is required; the necessary pressure is imparted by the weight of your body.
- In this way the patient's abdomen is pressed against the ground; the abdominal organs are forced against the diaphragm; the diaphragm rises and air is driven out of the lungs together with any water or mucus which may be present in the air passages or in the mouth, producing expiration.
- Induce inspiration: Swing your body slowly backwards to its first position thus removing the weight from the hands (which are kept in position) and relaxing the pressure on the abdomen.
- The organs now assume their former position, the diaphragm descends, the throat is enlarged and air passes into the lungs, producing inspiration.
- Alternate these movements by a rhythmic swaying forwards and backwards of your body from the knee joints, twelve times a minute.
- The rhythm is pressure two seconds and relaxation three seconds.

Sylvester's method

- This method is to be used only when it is impossible to turn the patient on to his face.
- Adjust the patient's position; without wasting a moment, place the patient on his back on a flat surface, inclined if possible from the feet upwards.
- Undo all tight clothing.
- Raise and support the shoulders on a small firm cushion or folded article of dress placed under the shoulder blades.
- Sylvester's method of artificial respiration. Left-Inspiration; Right-Expiration.
- Maintain a free entrance of air into the windpipe. An assistant must catch hold of the patient's tongue with a handkerchief, draw it forward as far as possible, and hold it in that position.
- If this is not done there is a great danger of obstruction of the windpipe by the tongue falling back over the top of it.
- Imitate the movements of breathing. Induce inspiration: Kneel at a convenient distance behind the patient's head and grasping his forearms just below the elbows, draw the arms upwards, outwards and towards you, with a weeping movement, making the elbows touch the ground.
- The cavity of the chest is thus enlarged and air is drawn into the lungs.
- Induce expiration:- Bring the patient's flexed arms slowly forwards, downwards and inwards; press the arms and elbows firmly on the chest on each side of the breast-bone.
- By this means air expelled from the lungs.
- Repeat these movements alternately, deliberately, and perseveringly about twelve times a minute. The rhythm is pressure two seconds and relaxation three seconds.



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Mouth to mouth resuscitation

- * This is the simplest and an effective method which can be used during emergency.
- * In this method, the rescuer or first-aiders blows air forcibly into the patient's mouth or nose to inflate his lungs and stimulate the act of inspiration.
- * No efforts are required for expiration of air as it occurs due to the recoil of the elastic chest walls.
- * When applying the method the first aider kneels down behind the head of patient, puts his face on the patient's face and blows his own breath hard

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- When applying the method the first aider kneels down behind the head of patient, puts his face on the patient's face and blows his own breath hard into the patient's mouth.
- After the blowing the first-aider moves his face aside, takes a deep breath and again blows his breath into the mouth of the patient.
- This operation is continued till the patient shows signs of breathing.
- A rhythm of 12 to 15 operations/min should be maintained.
- The method may be considered unhygienic but where the patient's life is to be saved, considerations of hygiene have to be brushed aside.



Rescue stations

- Rescue stations for helping the mining industry have been established by the Central Government at central places
- These are under the management of Coal India Ltd subsidiary companies like BCCL, ECL, WCL, etc. functioning in the area.
- A rescue station is under the control of Superintendent of Rescue Station and has in its employment one or more rescue brigades which consist of workers trained in rescue operations with different type of rescue equipment and having experience of underground mining.
- The members of the rescue brigade are able to perform miscellaneous jobs like that of a mason, timber setter and others.
- The rescue station is equipped with equipment's of different types such as self contained compressor oxygen apparatus, reviving apparatus, gas mask, self rescuer, smoke helmet, pressure hose mask, etc. and has facilities for regular inspection, repairs and maintenance of the equipment.
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- A rescue brigade consists of 5-6 members, including a leader all of whom stay near the rescue station and undergo regular training and exercise daily at the rescue station, and sometimes at the mines.
- The brigade members have to be in constant readiness to attend any emergency call demanding their services and when a mine requires help of a rescue team, the mine authorities have to telephonically inform the rescue station and brigade is available at the spot within the shortest possible time.
- Each rescue station trains selected mine workers of nearby mines for rescue operations and keeps a list of such trained workers for summoning them in case of emergency at any mine within the area covered by the concerned rescue station.
- Some mines have their own rescue stations, e. g. at Mosabani Copper mines, Kolar Gold Field mines, etc.

Rescue Stations

- Rescue stations Central Govt. के द्वारा establish किया जाता है,
- Management Mining Companies के द्वारा देखा जाता है,
- Superintendent के control में होता है
- एक or अधिक Rescue brigades होती है
 - ↳ Rescue trained persons की रखा जाता है,
 - ① With different rescue equipments
 - ② have UG mining experience.

Equipments at rescue station

- ① Self contained compressed oxygen apparatus
 - ② Reviving apparatus
 - ③ Gas Mask
 - ④ Self rescuer
 - ⑤ Smoke helmet
 - ⑥ Pressure hose mask
- Facility of → Regular inspection } of equipment.
→ Repair
→ Maintenance

- Rescue brigade में 5-6 members होते हैं,
 - ↳ Including leader
 - ↳ इनके members rescue station पास ही रहते हैं,
 - ↳ Regular training करते हैं

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 ↳ इसके members rescue station पास ही रहते हैं।
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 &
 exercise
- Rescue brigade हर alert रहता है कि किसी भी emergency call को service देने के लिए
 ↳ Within shortest time possible will reach the mine
 ↳ Mine authorities इससे telephone की help से contact करेंगे।

Rescue operations at the mine

- The rescue team has to establish a fresh air base from where the team proceeds into the affected part of a mine.
- Such fresh air base is as close to the affected part as possible and, as the name suggests, has to be at a place where fresh respirable air, unpolluted by fire or explosion is available.
- If the entire mine is affected by a fire or explosion the fresh air base is at the surface at the start of rescue operation; otherwise it is underground at a suitable place close to the irrespirable zone of the mine.
- The fresh air base is equipped with the following persons and materials.

Rescue operations at the mine

- Rescue team affected area के पास Fresh air base बनाएगी
- अगर पूरी mines ही fire/explosion के कारण affected हैं तो fresh air base surface पर बनाया जाता है।
- ① near affected area
 - ② Fresh respirable air
 - ③ Unpolluted air by fire or explosion

- Two men of whom one is rescue trained.
- A rescue team consisting of 5-6 persons including a leader, fully equipped with self contained breathing apparatus and ready for service. Such team is in addition to one that goes inbye.
- Rescue equipment like reviving apparatus, smoke helmet, gas mask, etc.
- First aid equipment, stretchers, tools and mining supplies of all kinds likely to be required during rescue and recovery work, bleaching powder as disinfectant when removing dead bodies.
- Flame safety lamps, munia birds and other means of detecting carbon monoxide to ascertain the atmospheric conditions at the base itself.
- Hygrometer, Drinking water, Mine plan and rescue tracing on a large scale.

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- Hygrometer, Drinking water, Mine plan and rescue tracing on a large scale.
- Fire extinguishers.
- The rescue team has to proceed inbye of the fresh air base as a complete unit and no member is allowed to stay away.
- The leader leads the team and each member occupies a definite place as the team is on the move.

→ Fresh Air Base is equipped with :-

- ① 2 men जिसमें एक Rescue trained होना चाहिए
- ② 5-6 persons की Rescue team ready for service with equipments
- ③ Rescue equipments
- ④ First aid equipment → stretchers
→ First aid kit
→ blanket
- ⑤ Flame safety lamp, munia birds or other to detecting equipments
- ⑥ Hygrometer
- ⑦

- If any member experiences trouble due to physical causes or due to any defect in the apparatus; the entire team has to return to the fresh air base.
- The wearer has to communicate with others only by nods, hand signals and coded sounds of horns since speaking would endanger the wearer's life in toxic atmosphere.
- The mine manager or responsible authorities should advise the team leader on what the team has to do where it has to proceed.
- The instructions should be in writing accompanied by a plan of the district.
- If possible, a rescue trained worker familiar with the district should be included in the team.
- The rescue team has to complete its assignment within the period limited by the duration of the self-contained breathing apparatus and it should return to the fresh air base within that period.

→ Rescue operation करते समय अगर कोई भी member को परेशानी महसूस होती है तो पूरी team fresh air base में वापस आ जायेगी

→ Physical Causes
→ Defect in apparatus

→ Wearer communicate करने में लिड हथारी का use करेगा
↳ ① Nods

परेशान रहेंगे हमें होता है तो पूरा team
 के वापस आ जाइगी
 → Physical causes
 → Defect in apparatus
 → Weavers communicate करने में लिड हंगामी का use करेगा
 (1) Nods
 (2) hand signals
 (3) Coded sounds of horns.

→ Team किस प्रकार से rescue operation करेगी इसकी responsibility Mines manager or other responsible authority की होगी

→ Instructions will be given in writing with plan of the area (district)

→ अगर कोई rescue trained worker उस district के बारे में जानकारी रखता है तो उसे भी team में include किया जाइगा

→ Rescue team limited समय में rescue का work complete करेगी
 ↓
 It depends on duration SCBA

→ Rescue team का कोई भी member दीवार से rescue work के लिए तब तक नहीं जाइगा जब तक medically fit certified ना हो।

→ Team के द्वारा जो भी Route follow किया जाइगा उस रास्ते Chalk से mark कर देंगे।

- No member of the rescue team should be asked to do a second spell of work, unless medically examined and certified fit.
- The route followed by the team must be marked in chalk and if the atmosphere is smoky and the visibility poor, a lifeline must be extended from the base as the team proceeds inbye.
- A lifeline is a thin white polythene rope.
- The leader should not engage himself in manual work but should supervise and direct the work of his team members
- The team should not proceed inbye unless the roof is safe or made secure by the team.

Distance covered depends on:-

- Capacity of the apparatus.
- If the apparatus is provided with oxygen to last two hours, the rescue team must return to the fresh air base within one hour and 45-50 minutes.
- If the apparatus of any rescue member develops any defect the whole team must return to the base.
- The temperature of the underground atmosphere, the gradient of the roadways and the load carried by the team influence the team's capacity to work and the distance they can cover.
- Obstructions in the roadway like roof fall, twisted rails, tubes jammed upto the roof, etc. A roomy well supported roadway free from roof falls will enable the team to cover a longer distance
- If the team has to mark on the rescue tracings such details as cross-sections of the roadways for constructions of stoppings, position of machinery and other obstructions thrown away in the roads by the explosion, etc. the distance that can be covered is naturally less
- Physical condition of the least efficient member of the team as the whole brigade has to

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Physical condition of the least efficient member of the team as the whole brigade has to travel and work together.

The fresh air base is advanced from time to time as the team as the exploration proceeds.

Distance Covered depends on:-

① Capacity of apparatus

② अगर 2 hours का oxygen वाला apparatus है तो team within 1 hour fresh air base में वापस आ जाइगी

③ अगर किसी team member का apparatus खराब होत है तो पूरी team fresh air base में वापस आ जाइगी

④ Load Carried by team and temperature of U/g atmosphere.

⑤ Obstructions → Roof fall
Twisted rails
Tubes Jammed upto roof

⑥ Team has to mark rescue tracings

⑦ FAB की exploration होने के साग-साथ भारी बदला पड़ता है।

Difficulties in rescuing

- The shaft, cages and headgear may be damaged and unsafe for travel.
- Telephonic communication to underground may be disrupted.
- Surface fan may be damaged and ventilation de-arranged by short circuit of the air current through broken stoppings, blown up ventilation doors, damaged air crossings roof falls, etc.
- Underground roads are blocked by roof falls, tubs or mine cars jammed up upto the roof, machinery and materials thrown in the way, twisted rails, cables etc.
- Smoke and dust considerably brings down the visibility.
- Fumes, noxious gases and afterdamp are fatal to the men attempting to rescue.
- A gas explosion is sometimes followed by a series of explosions at short intervals.
- Fires may be caused by the explosions.
- Their smoke fills the roadways rendering them impassable, and also dangerous due to presence of carbon monoxide.
- Lack of ventilation and heat of explosion raises the temperature of underground atmosphere considerably high.
- Delivery pipes of pumps may be broken and water filled in the depressions on the routes. Deep areas may be flooded.

Difficulties in Rescuing

① Shaft, cages or headgear damaged है तो travelling unsafe हो जाता है।

② U/G telephone की condition खराब

③ Surface fan damaged → Ventilation का rearrangement हो जाता है।

④ U/G roadways roof fall है (broken stoppings)

within 1 hour fresh air base में वापस आ जाइगा

- ① अगर किसी team member का apparatus खराब होना है तो पूरी team fresh air base में वापस आ जायगी
- ① Load carried by team and temperature of U/g atmosphere.
- ① Obstructions → Roof fall
→ Twisted rails
→ Tubes jammed upto roof
- ② Team has to mark rescue trainings

⑦ FAB की exploration होने के साग-साच आती बरत पड़ता है।

Difficulties in rescuing

The shaft, cages and headgear may be damaged and unsafe for travel
Telephonic communication to underground may be disrupted.

Surface fan may be damaged and ventilation de-arranged by short circuit of the air current through broken stoppings, blown up ventilation doors, damaged air crossings roof falls, etc.

Underground roads are blocked by roof falls, tubs or mine cars jammed up upto the roof, machinery and materials thrown in the way, twisted rails, cables etc.

Smoke and dust considerably brings down the visibility.

Fumes, noxious gases and afterdamp are fatal to the men attempting to rescue

A gas explosion is sometimes followed by a series of explosions at short intervals

Fires may be caused by the explosions.

Their smoke fills the roadways rendering them impassable, and also dangerous due to presence of carbon monoxide.

Lack of ventilation and heat of explosion raises the temperature of underground atmosphere considerably high.

Delivery pipes of pumps may be broken and water filled in the depressions on the routes.
Deep areas may be flooded.

Difficulties in Rescuing

- ① Shaft, cages or headgear damaged है तो travelling unsafe हो जाता है।
- ② UG telephone की condition खराब
- ③ Surface fan damaged → Ventilation का rearrangement होना पड़ता है।
- ④ UG roadways roof fall के कारण blocked रहते हैं।
- ⑤ Smoke & dust के कारण Visibility नहीं रहती
- ⑥ Fumes, noxious gases and afterdamp के कारण rescue men affected रहते हैं।
- ⑦ Gas explosion के कारण short interval में बहुत सारे explosion हो सकते हैं।
- ⑧ Explosion के कारण आग लग सकती है।
- ⑨ Presence of Carbon monoxide
- ⑩ Lack of ventilation & heat of explosion raises temperature
- ⑪ Pumps की delivery pipes damage होती है जिसके कारण dip side routes में पानी भर रहता है।

① broken stoppings
② Ventilation doors blown up.
③ Damaged air crossings

MINING GYAN

Recovery work in mine

- An area in an underground part of a mine might have been sealed due to spontaneous heating, explosion, fire, irruption of noxious or inflammable gases or completion of depillaring operations.
- In some cases an area may be sealed by isolation stoppings after the completion of development if depillaring is planned to take place after a long time.
- Recovery of an area sealed due to fire or explosion is not free from risks and some preparatory work is essential before connecting the operations to recover the area.

Recovery work In Mine

- Underground mines किसी भी इस area को seal करता है due to →
- ① Spontaneous heating
 - ② Explosion
 - ③ Noxious or Inflammable gases.
 - ④ Completion of depillaring operations.
- Sealed off करने के लिए isolation stopping use किया जाता है।

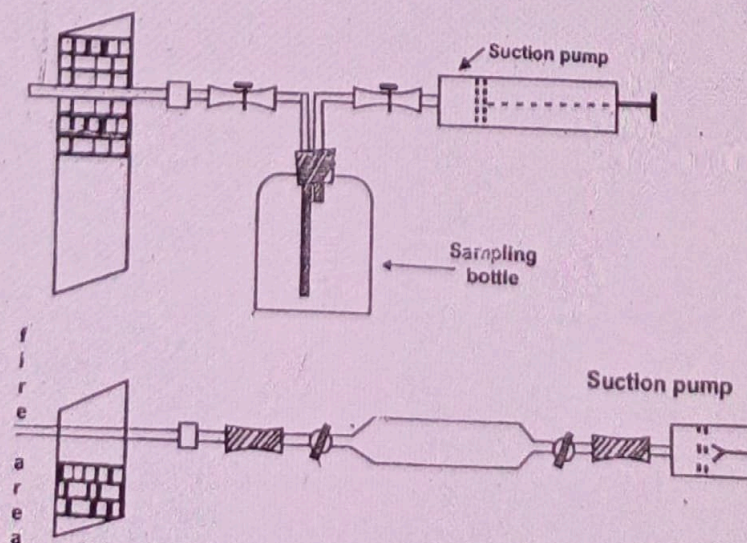


Fig. 7.1 Collecting samples with the help of a suction pump.

RUBBER
CAP



FUEL
MARK



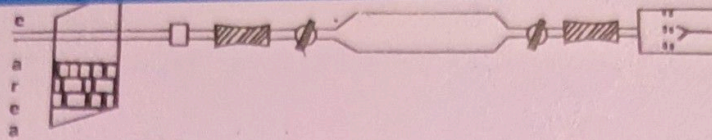
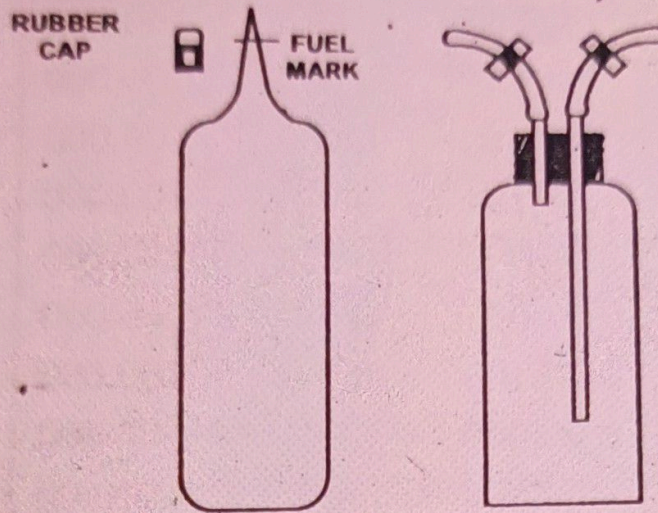


Fig. 7.1 Collecting samples with the help of a suction pump.



Reopening a sealed off fire area

- Before taking a decision to reopen a sealed off fire area the mine authorities have to ascertain the conditions behind the stoppings in respect of temperature, state of fire, composition of gases and their pressure.
- The temperature of the stopping, as felt by hand, gives the indication whether the temperature of the sealed off fire area is increasing or decreasing.
- This is reliably observed from the thermometers inserted in the stoppings through built-in pipes.
- Other aspects of the conditions behind the stoppings can be known after interpretation of the analysis of the gas samples taken from the sealed area at regular intervals over a long period.
- Such samples should preferably be collected when the pressure behind the stoppings is positive.
- It is recommended that samples should be taken when the barometric pressure is low (between 12 noon and 2 P.M.)
- Samples may also be collected by the method of water displacement.
- In all cases samples should be collected from sampling pipes which are at least 3m inside the stopping and the air which was present in the sampling pipe should be allowed to escape before the proper sample is taken..

Reopening a sealed off fire area.

- Stopping के पीछे की condition के बारे में जाना जाता है
- Temperature
 - State of fire
 - Composition gases
 - Pressure

- Experienced Supervisory staff → stopping पर हाथ रखकर temperature को feel करना
- ↓
- Thermometer को sampling pipe में लगाकर use कर सकते हैं

- Such sample would be representative of the atmosphere behind the stopping and would be reliable.
- If a rescue team wearing self contained breathing apparatus has to collect spot samples after entering a sealed area, the samples are collected in the following manner.
- By displacement of water: The bottle should be filled with clean surface

stopping and would be reliable.

- If a rescue team wearing self contained breathing apparatus has to collect spot samples after entering a sealed area, the samples are collected in the following manner.
- By displacement of water: The bottle should be filled with clean surface water and not by mine water. It is preferable to fill the bottle with acidified water coloured with methyl orange.
- The moisture on the inside surface of the bottle may, however dissolve small quantity of soluble gases like CO_2 .
- By inflating a rubber bladder with an air-filling pump at the spot of sample
- By breaking the neck of a vacuum sampling bottle at the spot where sample of air is to be collected. It is instantaneously filled with the air sample and is then sealed by a rubber cap. The vacuum bottles are usually 250-300cm.

→ Analysis of Gas → Samples collect करना है

at regular intervals

① Samples तभी collect करें जब stopping के पीछे +ve pressure हो।

② अगर Pressure -ve है तो suction pump का Use करें

→ In case of +ve pressure → by water displacement method

② Vacuum sampling bottle
spot पर उसके neck को break करते हैं air उसमें भर जायेगी

bottle में moisture रहना है जिसके कारण उसमें CO_2 dissolve हो जायेगा & % कम show करेगा

→ water displacement method / Vacuum sampling bottle

↳ ① +ve pressure behind stopping

② By Rescue Team wearing SCBA

③ Spot sampling after entering sealed of area.

Interpretation of analysis of gas samples

- If the fire is active there is gradual decrease in percentage of oxygen, gradual increase in percentage of CO_2 (say upto 5 or 6%) and the ratio of CO_2 formed/ oxygen absorbed is high.
- $\text{CH}_4\%$ goes up rapidly in a gassy mine
- When the percentage of O_2 falls below nearly 12%, actual flame ceases but the members continue to be hot and slow combustion continues when $\text{O}_2\%$ is as low as 4-5 resulting in formation of CO and CO_2 and evolution of heat.
- The percentage of CO_2 and CO gradually goes down and that of CH_4 gradually increases.
- When the percentage of oxygen comes down to nearly 2 and remains at that level or below for some weeks the fire may be considered to be extinct.
- The CO/O_2 ratio at that stage is nearly the same as is normal to the coal seam when it was being worked.

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- The CO/O₂ ratio at that stage is nearly the same as is normal to the coal seam when it was being worked.
- The CH₄ percentage gradually goes up and the atmosphere behind the stoppings is practically full of CH₄

Interpretation of Analysis of gas samples.

- Decrease in % of Oxygen → Fire active
- $\frac{\text{CO}_2 \text{ formed}}{\text{O}_2 \text{ absorbed}}$ का ratio high होता है।
- Oxygen → below 12% → आग कुछ घुंकी है लेकिन चीजें अभी भी बहुत गर्म हैं and slow combustion कर रहे हैं।
- 4-5% O₂ तक slow combustion चलता रहता है।
- CO + CO₂ + heat
- CO & CO₂ का % decrease होगा → CH₄ का % increase होगा
- Oxygen % below 2% → कुछ बचता है और आग completely बुझ जाती है
- Fire is dying → O₂ % decrease
- CO₂ % remains constant, or constant increase
- O₂ % decreases → stoppings air tight हैं (leakage नहीं हो रहा है)
- CH₄ % → Mine is gassy.

- The analysis indicates that oxygen percentage is gradually falling and CO₂ percentage is steadily rising. The ratio CO/CO₂

- The analysis indicates that oxygen percentage is gradually falling and CO₂ percentage is steadily rising. The ratio CO/CO₂ is nil and CO/O₂ gradually rises.
- This is indicative that the fire is dying.
- The fact that the oxygen percentages is gradually falling indicates that the stoppings are reasonably airtight and mine air not leaking into the fire area.
- Methane percentage indicates that the mine is only nominally gassy.

Conclusions

- Active combustion occurs chiefly during the first 6 or 8 days and during this period the percentages of CO and CO₂ increase but the percentage of oxygen goes down and the fire gradually dies down with the fall in oxygen percentage.
- Slow heating continues throughout most of the period till the oxygen percentage falls down to 2% at the intake stopping.
- At the end of 58 days the fire is completely extinguished.
- It is however prudent to wait for a few months more and watch the trend of temperature and gas analysis before contemplating to reopen the fire area.
- The seals are reasonably airtight as there is no fluctuation in the percentages of oxygen and nitrogen and the CH₄ percentage is gradually rising without any dilution by leaking air.
- There is danger of firedamp explosion between the 3 and 6 or 7 days, i.e. when the percentage of CH₄ lies within 5% and 15% and the percentage of oxygen exceeds about 13%.
- Thereafter no such danger exists partly because the percentage of CH₄ is too high and partly because the percentage of oxygen is too low.
- It should be noticed that the figures of analysis at the return stoppings are more important for purposes of interpretation.

Conclusions

→ Active Combustion → आग starting के 6-8 days तक जलती है
 ↳ during this period
 ↳ ① % of CO & CO₂ increases
 ② O₂ % decreases

→ Slow heating → यह तब तक होता है जब तक O₂ का % गिरकर 2% पर नहीं आ जाता है।

→ 58 days के बाद fire पूरी तरह बुझ जाती है।

→ Reopening करने के पहले कुछ दिनों तक wait करिए and temperature/gas analysis करिए

→ Airtight Stopping → अगर O₂ के % में कोई fluctuation नहीं हो रहा है and CH₄ का % बहुत तेजी से बढ़ रहा है तो इसका मतलब leakage नहीं है।

→ Danger of firedamp Explosion → 3 से 7 days तक खतरा बना रहता है
 ↳ इस बीच CH₄ का % 5-15% होता है and O₂ का more than 13% होता है।

हूशका मतलब leakage नहीं है।

→ Danger of fire damp Explosion → 3 से 7 days तक खतरा बना रहता है

↳ हूश बीच CH_4 का % 5-15% होता है and O_2 का more than 13% होता है।

→ उसके बाद CH_4 का % हमला high होता है जो की fire damp explosion नहीं होता

- If the analysis of air samples points towards fire extinction and the temperature of the area has come down to the normal strata temperature and these conditions remain constant for a few months, the stage is ripe for reopening the fire area.
- Before the fire area is to be reopened the mine authorities have to inform the DGMS of their intention to reopen the sealed workings
- The area is then inspected by a rescue team wearing self contained breathing apparatus after breaking open only one of the fire stoppings just sufficient for entry.
- Before the rescue team is allowed to enter the area the following precautions should be taken:-
- The roadways leading to the affected fire area should be thoroughly stone dusted.
- The return airway by which gas under pressure from behind the stoppings may travel to the upcast shaft should be free from any possible source of ignition and electric current should be switched off from all the equipment in the return air route.
- Water mains and telephones should be extended upto the fire stoppings. Materials and men for sealing off the fire area and construction of stoppings should be kept ready at hand

→ Before Reopening → DGMS को inform करें

↳ Mine authorities के द्वारा किया जायगा

→ Rescue team SCBA पहन कर inspection करती है।

↳ fire stopping को तोड़ कर अंदर जाते हैं

↳ Sufficient for entry.

→ Precautions by Rescue Team

- ① fire area की तरफ जाने वाली roadway में heavy stone dusting करें
- ② Return airway में कोई भी source of ignition नहीं होना चाहिए

③ Telephones lines & water supply को fire stopping तक extend करें

④ Stopping को seal करने के लिए men & material हर वक्त ready रहने चाहिए

⑤ haulage track को stopping तक extend करें (if possible)

⑥ Large scale plan पर district की information rescue team के द्वारा mark किया जायगा

↳ Temperature

⑦ Water logging

⑧ Roof falls

⑨ Blocked road

⑩ Site of gas sample

⑪ Position of machinery

⑫ Condition of ventilation

- ④ Stopping को seal करने के लिए men & material हर वक्त ready रहने चाहिए
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→ Temperature

① Water logging

② Roof falls

③ Blocked road

④ Site of gas sample

⑤ Position of machinery

⑥ Condition Ventilation Stopping

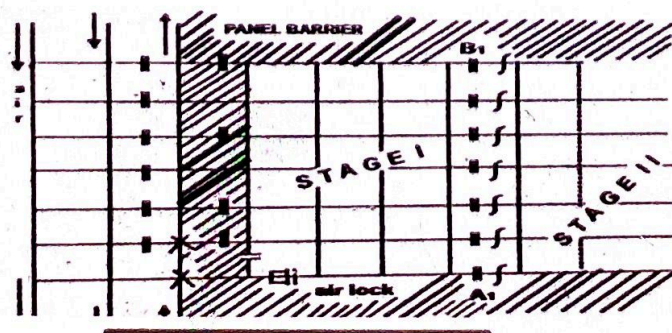
- If possible haulage track should be extended upto the stoppings or a convenient place near it.
- The rescue team marks on the large scale tracing of the district the information it gathers during inspection in respect of temperature, water logging, roof falls, road blockade, sites of gas samples, position of machinery, condition of ventilation stoppings and doors, etc.
- Such information and the interpretation of gas samples help the management to take a decision on reopening the sealed off fire area.
- If the sealed off area is small the whole area is ventilated by breaking one stopping on the intake air route and one on the return air route, thereby circulating the air current through the district. It is preferable to construct a regulator in the return air stopping of the district to be reopened before circulation of air.
- The sealed off area should be thickly stone dusted.
- It is to be noted that host coals or other material may remain buried under ashes and roof falls and on admission of fresh air the fire may be revived. The area has therefore to be kept under observation for indication of smoke or rise of temperature.
- Samples of air from the return airway of the district should be taken at half hourly intervals and speedily analysed for proper interpretation.

⑦ Sealed off area में heavy stone dusting किया जाइगा

⑧ District के return airway से हर आधे घंटे में air के samples collect किए जाइंगे

Reopening a sealed of area in stages

- When the sealed off area is large and inspection by the rescue team in one stretch is impossible due to the extent of the area, numerous roof falls, water logging or some other reasons, it should be reopened in stages



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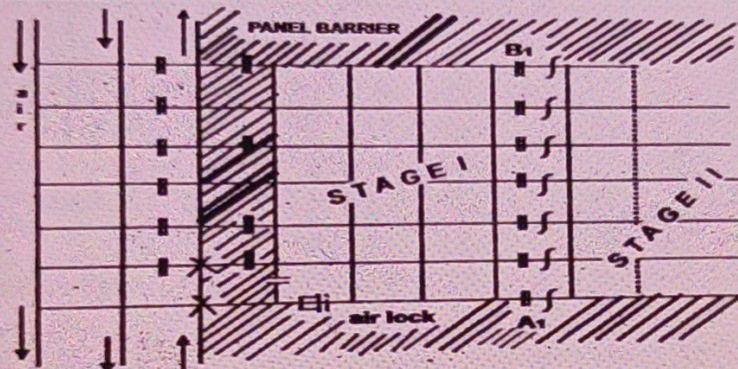


Fig. 7.4 Reopening a sealed off area in stages

Procedure of reopening in stages

- Build an airtight airlock comprising of two steel doors on the outbye side of the stopping of proposed intake airway.
- Establish fresh air base on the outbye side of the airlock.
- Breach only one stopping inbye of the airlock just sufficient to allow the rescue team to enter.
- Permit the rescue team to inspect the area only upto a specified distance, generally 50 to 100 m.
- If report of the rescue team indicates condition favourable for reopening part of the area, another rescue team should be sent inbye to inspect a further area, say upto 200m inbye and on receiving a report from the second rescue team a decision should be taken on the total area to be reopened.
- Construct **temporary stoppings** to separate the area to be recovered from the area which will not be recovered in the first stage.

Procedure of Reopening In Stages

- 1) Air tight - airlock बनाए जिसमें की intake airway की side में 2 steel doors होने चाहिए
- 2) Airlock के बाहर Fresh air base बनाए
- 3) Break one stopping sufficient to enter rescue team
- 4) Rescue का काम सिर्फ 50 से 100m तक ही किया जाइगा।
- 5) अगर सब कुछ ठीक है तो आगे 200m तक Rescue किया जाइगा
- 6) Stages की अवस्था करने के लिए temporary stopping बनाए

- Break stopping of the proposed return air route after constructing a temporary stopping on its inbye side.
- Open the door of the airlock to allow only small quantity of air, about 20 m³/min, to circulate past the temporary stoppings till the gas percentage falls to about 2% and keep the area under observation for rise of temperature.
- Construct permanent brick stoppings in front of the temporary stoppings

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- Construct permanent brick stoppings in front of the temporary stoppings and provide doors in them at A1 and B2 Transport of material, etc. can be done by mine workers but rescue teams equipped with self contained breathing apparatus should be kept in readiness at a nearby convenient point.
- For recovery of the area inbye of the stoppings A1 and B1 in stages construct an air lock at A1 and repeat the same procedure as outlined above.
- An auxiliary forcing fan may be used for ventilation of the recovered area if the return air route is blocked by roof fall machinery or other causes.
- Use of suction fan is not recommended as the air of the scaled area may be charged with fire damp.

⑦ Temporary stopping बनाने के बाद Return side के एक stopping को तोड़ देंगे

⑧ Airlock के doors को खोल देंगे → To Circulate 20m³/min of air ताकि gas % कम हो जाइस
Upto 2%.

⑨ Temporary stopping के सामने Permanent stopping बनाइ

⑩ अगर Roof fall के कारण Return airway blocked हो तो recovered area को ventilate करने के लिए auxiliary forcing fan Use करें

⑪ Suction fan Use नहीं करना है because of presence of firedamp.

MINING GYAN

Mine Lighting

- Cap Lamp
- Flame Safety Lamp
- Electric torch

Terms Related to Lighting

→ Intensity of Light $\Rightarrow$ amount of light energy given by source

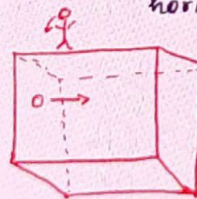
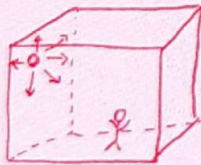


$\Rightarrow$ CGS Unit $\Rightarrow$ Candles / Candle Power

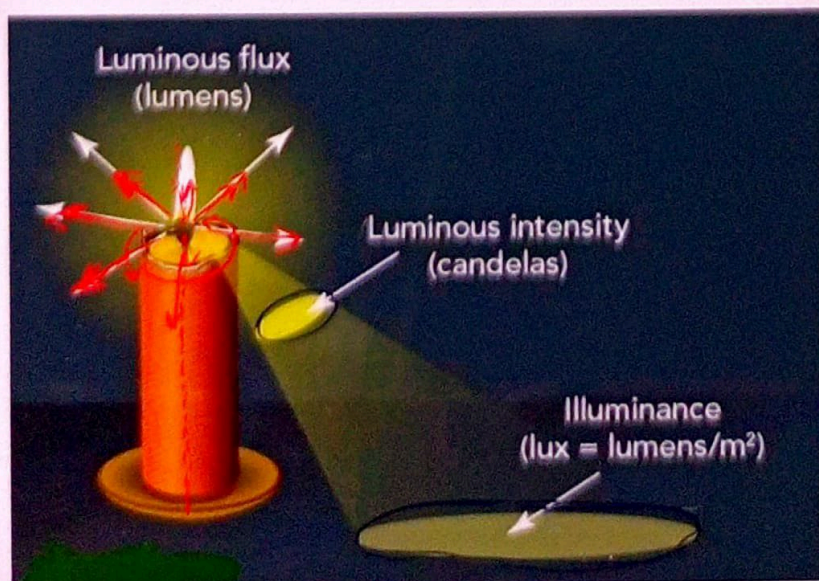
Light source

अलग directions में अलग अलग intensity देता है

→ Mean horizontal Candle power (mhcp) $\rightarrow$ Avg. candle power in all directions in a horizontal plane.

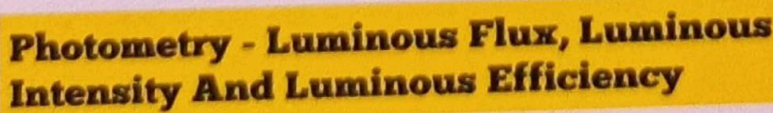


→ Mean spherical Candle power $\rightarrow$ Avg. candle power in all directions.



Illumination $\rightarrow$ 1 candela light produce करने वाला source के कारण 1 m की दूरी पर रखे हुए surface पर light की intensity

→ A metre candle is also called lux.

$$\rightarrow \text{Illumination} = \frac{\text{Candela of source}}{\text{distance in m}^2}$$
$$\text{Illumination} = \frac{1}{(1)^2} = \frac{1 \text{ lux}}{1 \text{ candela}}$$
$$\Rightarrow 2 \text{ m at distance} \quad \text{Illumination} = \frac{1}{2^2} = \frac{1}{4} = 0.25 \text{ lux}$$


measurement $\Rightarrow$ lumen (lm)
Luminous Intensity or Illuminating Power (I)

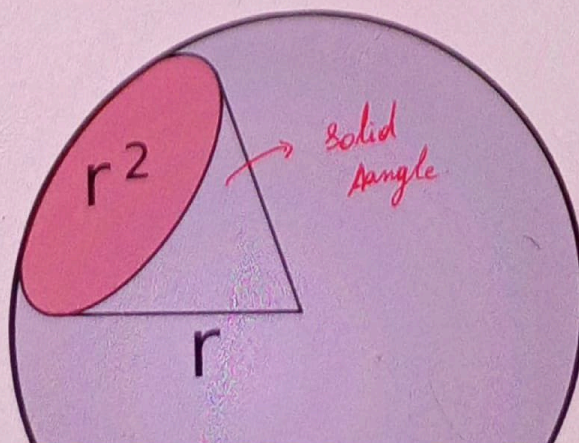
- Luminous flux Φ Luminous Power (Φ)
- Light source se per second nikalنے वाली किरणों का Luminous flux कहते हैं।
 - Denoted by Φ
 - Unit of measurement $\Rightarrow$ lumen (lm)
 - Luminous Intensity or Illuminating Power (I)
 - Per unit solid angle se nikalने वाली luminous flux का I se luminous intensity कहते हैं।
 - Denoted by I

Luminous Efficiency

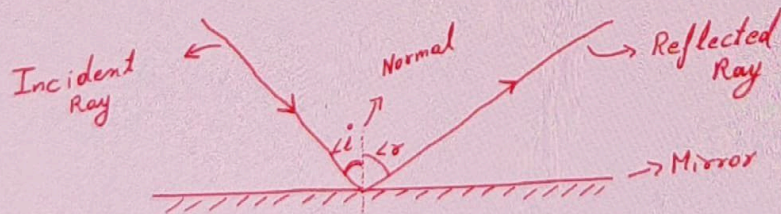
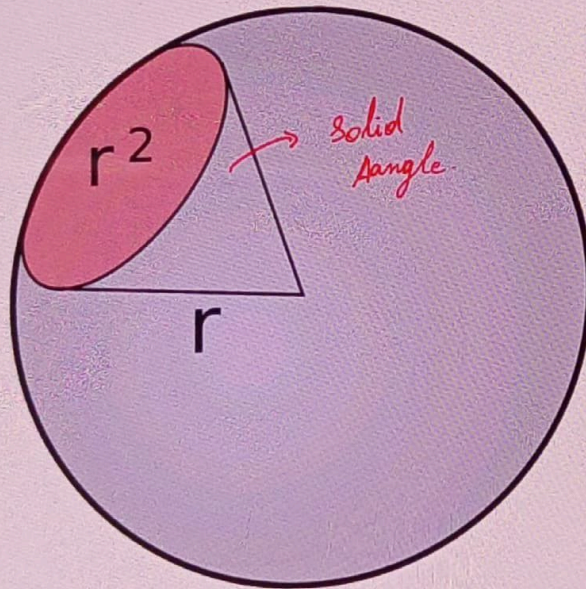
- Ratio of luminous flux to the electric power given to it
- Denoted by η

$$\eta = \frac{\text{Luminous flux in lumens}}{\text{Electric power given in Watt}} = \frac{\Phi}{P}$$

Term	Unit of Measure	Dependence
1) Intensity $(I) \rightarrow$	Candela (cd)	→ Direction Not on distance
2) Flux $(\Phi) \rightarrow$	lumen (lm)	→ Solid angle.
3) Illumination $(E) \rightarrow$	Foot candle (lm/ft^2) lux (lm/m^2)	→ distance & angle of incidence
4) Exitance $(M) \rightarrow$	lm/ft^2	→ reflecting surface
5) Luminance $(L) \rightarrow$	cd/ft^2	→ direction & Nature of surface



- 2) Flux (Φ) $\rightarrow$ lumen (lm) $\rightarrow$ Solid angle
- 3) Illumination (E) $\rightarrow$ Foot candle (lm/ft²) $\rightarrow$ distance & $\angle$ of incidence
 $\rightarrow$ lux (lm/m²)
- 4) Exitance (M) $\rightarrow$ lm/ft² $\rightarrow$ reflecting surface
- 5) Luminance (L) $\rightarrow$ cd/ft² $\rightarrow$ direction & Nature of surface



$\angle i$ = angle of incidence

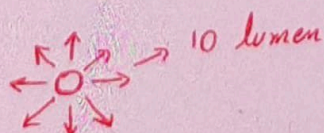
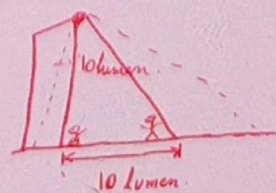
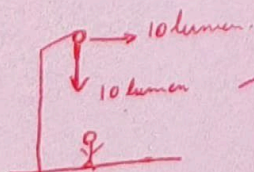
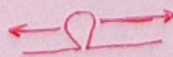
$\angle r$ = angle of reflection

Laws of reflection $\Rightarrow$ ① $\angle i = \angle r$

② Snell's law = $\sin i = \sin r$



10 H
10 V



MINING GYAN

Flame Safety Lamp

By - Devendra Singh Tomar

Flame Safety Lamp

- A safety lamp is one that does not cause an explosion in the presence of firedamp
- Earlier it was an oil lamp surrounded by a metal gauze to distribute the heat over a large area due to which gauze temperature remains below ignition temperature of gas.
- It was discovered by Sir Humphrey Davy in 1815.
- It was discovered with dual purpose of detecting methane as well as illumination.
- Nowadays flame safety lamps are based on Marasaut - Museler principle

Flame Safety Lamp

- Safety lamp is कारण firedamp से explosion
- Wire gauge → 2 wire gauges.
 - mesh → 20 mesh & 28 mesh.
 - heat को large area में distribute करता है जिससे कारण temperature gas के ignition temperature से कम रहता है।
- Discovery → Sir Humphrey Davy → in 1815
- Principle of Modern FSL → Marasaut - Museler Principle

Sections of FSL

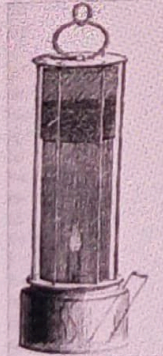
- ① Lower section →
 - Fuel vessel
 - Wick
 - Screw
 - Locking arrangement → Magnetic lock
 - Relighting device

- ② Middle section ⇒
- 2 set of rings
 - 5 steel rods.
 - Glass
 - Chimney
 - Two asbestos washer

- ③ Upper section ⇒
- Bonnet
 - 2 steel wire gauge
 - handle/hook.



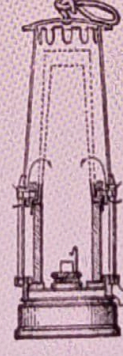
Clanny



Davy



Mueseler



Marsaut



Electric

Modifications in FSL

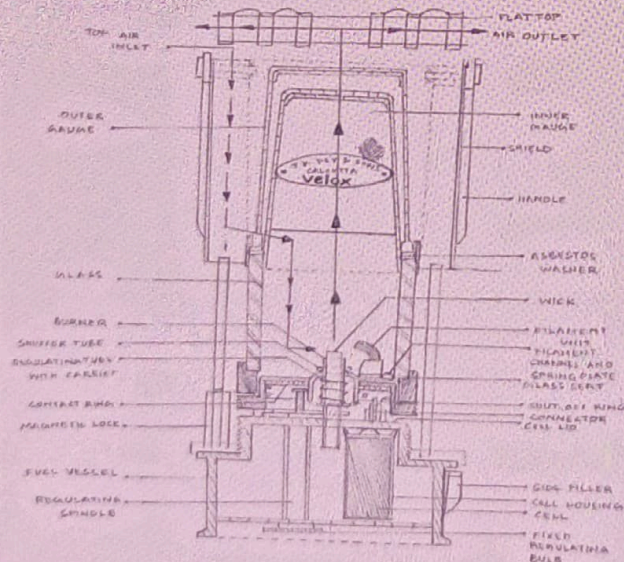
- Introduction of glass cylinder around the flame
- Addition of internal chimney
- Two gauzes instead of one
- Safety locks, arrangement for relighting, controlled air feeding arrangement

Sections of FSL

- Lower section
 - Fuel vessel, burner, wick assembly, a screw, locking arrangement and relighting device (if available)
 - Locking arrangement is generally of magnetic type. It can be opened only in the lamp room. Thus, once it is locked, it cannot be opened in the underground
- Middle section
 - Two sets of rings interconnected by the five steel rods, glass around the flame, chimney, two

Sections of FSL

- Lower section
 - Fuel vessel, burner, wick assembly, a screw, locking arrangement and relighting device (if available)
 - Locking arrangement is generally of magnetic type. It can be opened only in the lamp room. Thus, once it is locked, it cannot be opened in the underground
- Middle section
 - Two sets of rings interconnected by the five steel rods, glass around the flame, chimney, two asbestos washer
 - Ring and rod combination serves to protect the glass. Rings have holes to allow air in/out
 - Chimney is introduced to increase the illumination produced
 - Asbestos washer is used to make the assembly air tight.
- Upper section
 - A bonnet, two steel wire gauzes (20 or 28 mesh size), handle/hook
 - It is the wire gauze which is responsible for the working of FSL and not allowing the ignition of methane, even if present in the general body of air.
 - Handle serves the purpose of holding the lamp while detecting methane.



Working principle of FSL

- Wire gauze does not let methane to ignite even if there is methane in the general body of air.
- The ignition of methane is limited only to the interior of the lamp.
- The distance between the wire gauze and the mouth of the Bunsen burner is kept to be around 30mm.
- Flame will not cross the gauze wire until it gets red hot

Working Principle of FSL

→ Wire gauze, General body of air & methane ignite नहीं करती है।

- Bunsen burner is kept to be around 30mm.
- Flame will not cross the gauze wire until it gets red hot

Working Principle of FSL

- Wire gauze, General body of air की methane ignite नहीं करती होता है।
- Methane lamp के बंदर ignite होता है लेकिन इसका effect काटने नहीं आता है।
- Wire gauze and burner के mouth के बीच कम से कम 30mm का distance होना चाहिए
- जब तक wire gauze red hot नहीं हो जाता है तब flame इसका cross नहीं करेगा।

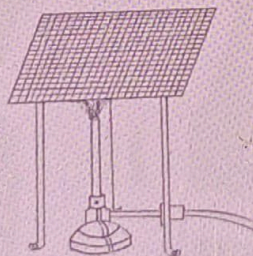
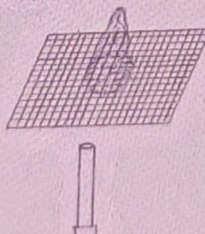


Fig. 2(a) Principle of wire gauze (after Deshmukh, 2008)



Principle of gauze wire

- It is made up of metals like copper or iron or steel
- Basically they conduct heat so quickly that the temperature above gauze wire is below the ignition temperature of the gas
- But once the wire becomes red hot, it is not able to conduct the heat and the temperature above it crosses the ignition temperature of the gas

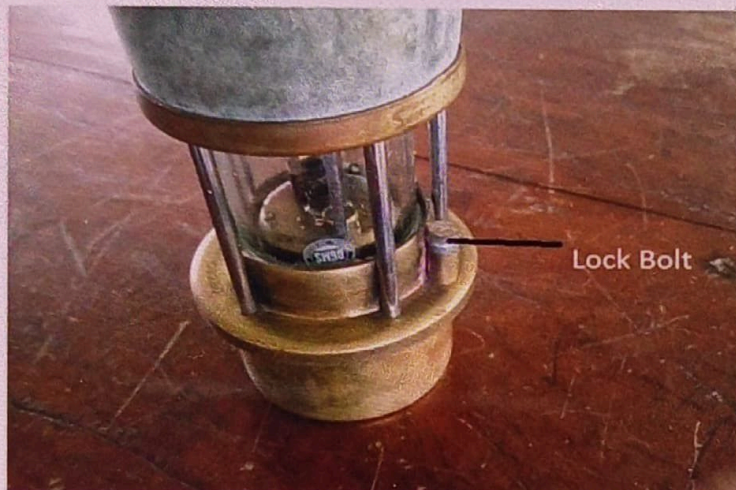


Fig. 3(a) Lock bolt in a Flame safety Lamp



Fig. 3(c) Magnetic unlocker

DGMS Approval Tests

- **Drop test** – The lamp has to be dropped for 5 times from a height of 1m to a hard wooden board. The board should be 30mm thick and should be laid on concrete. The test is passed by the lamp if no

Fig. 3(c) Magnetic unlocker

DGMS Approval Tests

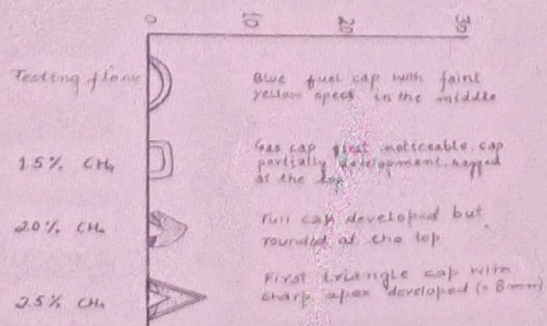
- **Drop test** – The lamp has to dropped for 5 times from a height of 1m to a hard wooden board. The board should be 30mm thick and should be laid on concrete. The test is passes by the lamp if no damage to any component of the lamp is observed
- **Test for air tightness** – After assembling the different sections of the lamp it is lit and held before a compressed air jet of velocity not less than 6m/s. The test is said to be passed if flame is not extinguished as well as no undue flickering should be observed
- **Performance test** – This is decided on the basis of length of the flame produced as well as condition (intensity, colour and its sensitivity towards methane concentration)

DGMS Approval Test

- **Drop Test** ⇒ - Lamp की 1m की height 30mm की thickness वाली wooden board पर 5 बार गिराया जाता है।
- wooden board concrete ground पर रखी होना चाहिए।
- **Test for Air Tightness** ⇒ Lamp की assemble करके 6 m/s ^{velocity} वाली compressed air के सामने रखते हैं।
- **Performance test** ⇒ Length of flame
- Intensity & Colour of flame.

Table 3 Performance test on flame safety lamp

Gas %	Minimum length of blue flame (mm)	Condition of blue flame
0.0	-	Near the top of the standard flame a slight cobalt-blue lined orange-yellow flame is seen
1.0	7.0	Blue flame is not observed because the flame color is light and hence it is difficult to measure the length
1.5	8.0	Lower part of flame turns blue
2.0	9.0	Blue flame is distinctly visible except at the top
2.5	10.0	Blue color becomes more visible, but still top is invisible
3.0	11.5	Top of flame is still invisible and blue flame is seen clearer
3.5	14.5	Blue flame is clearly visible
4.0	20.0	Blue flame is extremely clear, highly sensitive to slight change in methane concentration



0 10 20 30

Testing flame



Blue fuel cap with faint yellow spect in the middle

1.5% CH_4



Gas cap first noticeable, cap partially development, ragged at the top

2.0% CH_4



Full cap developed but rounded at the top

2.5% CH_4



First triangle cap with sharp apex developed (= 8mm)

3.0% CH_4



Triangular cap (= 12mm)

3.5% CH_4



Triangular cap (= 12mm)

4.0% CH_4



Triangular cap (= 28mm)

Specification for FSL

- Oil container – the container and the cap of the container shall be made of suitable material so as to be capable of resisting impact received in normal usage and not liable to any leakage. The filler cap shall be provided with a suitable washer so as to prevent oil leakage during normal working conditions
- Lock – The lock shall be of magnetic or of any other effective type and shall be of construction which shall not slacken or unlock during usage. The lead rivet locks shall not be used.
- Bonnet - The design of bonnet shall be such as to protect the gauzes and to ensure the mine ventilation current does not impinge directly on the gauzes. The top of the outer gauze shall not be less than 5 mm below the bottom edge of the outlet port.

Specifications of Flame Safety Lamp.

- 1) Oil Container $\Rightarrow$ Leakage proof
 $\Rightarrow$ Impact resistance
- 2) Lock $\Rightarrow$ Magnetic type
- 3) Bonnet $\Rightarrow$ Protect wire gauzes
 $\Rightarrow$ Mine air indirectly gauzes में जानें से रोकना
 $\Rightarrow$ Distance b/w Top of outer gauze and bottom edge of outlet port $\Rightarrow$ 5mm से कम नहीं होना चाहिए

- Gauzes - The safety lamp shall be fitted with a pair of gauzes, made of wires of steel, best charcoal annealed iron or other suitable material, meeting with any one set of the following requirements:-
 - Both gauzes of nominal wire diameter 0.38 mm and of aperture of 530 microns
 - Both gauzes of nominal wire diameter 0.42 mm and of aperture of 850 microns
 - Both gauzes of nominal wire diameter 0.46 mm and of aperture of 810 microns
 - The outer gauze shall have a heat radiating area of not less than 115 cm² and the inner gauze not less than 90 cm².
 - The distance between inner and outer gauzes shall not be less than 1.5 mm

Gauzes $\Rightarrow$ Made of steel wires.

$\Rightarrow$ heat radiating area
 $\hookrightarrow$ heat में वितरण (distribute) $\pm$ तब ही wire gauze का area.
 Outer gauze $\Rightarrow$ not less than 115 cm²
 Inner gauze $\Rightarrow$ not less than 90 cm²

of 810 microns

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Gauzes ⇒ Made of steel wires.

⇒ heat radiating area.

↳ heat ~~at~~ ^{is} ~~the~~ ^{the} (distributed) ~~at~~ ^{is} wire gauze ~~at~~ ^{is} area.

Outer gauze ⇒ not less than 115 cm²

Inner gauze ⇒ not less than 90 cm²

Distance b/w inner and outer gauze
↳ not less than 1.5 mm.

- Gasket (washer ring) - The gasket shall be made of non-flammable material, such as asbestos and shall not be less than 1.3 mm thick and 5 mm wide.
- Glass Cylinder - The glass cylinder shall be of hard glass, uniform in composition and thickness, optically clear, without colour tints and shall be free from bubbles, flaws, cloudiness, etc.
 - The thickness shall be 4.5 to 5.5 mm. The diameter and height of the glass cylinder shall be such as to ensure safety in the lamp when assembled.

Gasket (washer Ring) ⇒ non flammable material ~~at~~ ^{is} ~~the~~ ^{the}

⇒ made of asbestos

⇒ thickness ⇒ not less than 1.3 mm

⇒ width ⇒ not less than 5 mm.

Glass cylinder ⇒ Made of hard glass.

⇒ Uniform composition (सुदृढ़ संयोजन) ~~at~~ ^{is} ~~the~~ ^{the}

⇒ Uniform thickness ~~at~~ ^{is} ~~the~~ ^{the}

⇒ Optically clear, without colour tints ~~at~~ ^{is} ~~the~~ ^{the}

⇒ Thickness ⇒ 4.5 mm to 5.5 mm ~~at~~ ^{is} ~~the~~ ^{the}

Some more specifications

Some more specifications

- Rivet locking arrangement shall not be of lead type
- Thickness of glass cylinder shall be 4-5mm
- Total heat radiation area of the gauze should not be less than 155cm^2

Test

- Performance test
- Wind test
- Safety test
 - Still gas test
 - Flowing gas test
- Strength test
 - Lamp assembly
 - Gasket
- Glass cylinder test
 - Type test
 - Strength test
 - Temperature test

Safety Test

- Still gas test – Place the unlighted lamp in an enclosure and pass methane into the enclosure until the methane content is 8 to 10 percent. Cause an explosion inside the lamp by means of the self-contained relighter. Repeat the test at least ten times. The ignition of methane and air mixture external to the lamp shall not result in any case.
- Replace the fuel vessel by an ebonite or wooden base fitted with a spark gap and a tube for connection to an aspirating bulb. Place the assembly in an enclosure and pass methane into the enclosure until the methane content is 8 to 10 percent. Cause an explosion of the gas mixture drawn into the lamp by sparks across the spark gap induced from outside. Repeat the test at least ten times.

Manufacture of FSL in India $\Rightarrow$ JK Day & Sons.

$\hookrightarrow$ Trade name Velox.

① GL-5 $\rightarrow$ for accumulation test

② GL-50 } $\rightarrow$ for percentage test

③ GL-60 }

④ GL-7

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- ③ GL-60 }
- ④ GL-7

$\Rightarrow$ GL-5 $\Rightarrow$ 2 glass surrounding flame

$\Rightarrow$ used for accumulation test

$\Rightarrow$ Uses Kerosene oil

$\Rightarrow$ Mid-feed arrangement $\Rightarrow$ air mid-height of lamp at inlet $\frac{1}{2}$

MINING GYAN

GL-60 Flame Safety Lamp.

- bottom feed device लगा होता है
 - ↳ flame को air provide करता है
 - ↳ Relighting easy होता है
- general body of air में methane and CO_2 detect करने में help करता है
- Automatic Flame extinguisher → अगर fuel vessel को ईंधन remove करता है तो यह flame बुझा देगा
- self contained relighting mechanism
- Cotton absorbent in fuel vessel → fuel को बाहर गिरने से रोकता है।
- Fuel vessel में 2 cell वाली एक dry battery लगी होती है
 - ↳ 1.5V each
- Glass
- Filament channel
- Spring plate
- Buffer tube
- Contact ring.
- Spindle & Knob ⇒ wick/flame की height को change करना
- Relighting करने के लिए lamp को chest level तक ला कर Knob को clockwise घुमाना है।
- Knob को clockwise घुमाने पर:
 - ① Snuffer tube नीचे जाडगना जिससे कारण wick की length बढ़ जाडगी
 - ② battery का electric circuit complete होने के कारण filament Red hot हो जाडगा
- Wick के flame पकड़ने पर Knob को anticlockwise घुमाना है।
- battery किसी भी lamp की 600 times relight कर सकता है।

Lamp की Relighting में Problems.

- battery के Voltage में abnormal drop होने के कारण
- जलें हुए wick पर Coal dust का जम जाना

घुमाना है।

→ battery किसी भी lamp को 600 times relight कर सकता है।

Lamp की Relighting में Problems.

- battery का Voltage में abnormal drop होने के कारण
- उल्टे हुए wick पर Coal dust का जम जाना
- Damp wick
- Use of odd size of wick.
- कम या ज्यादा fuel का flow होना।

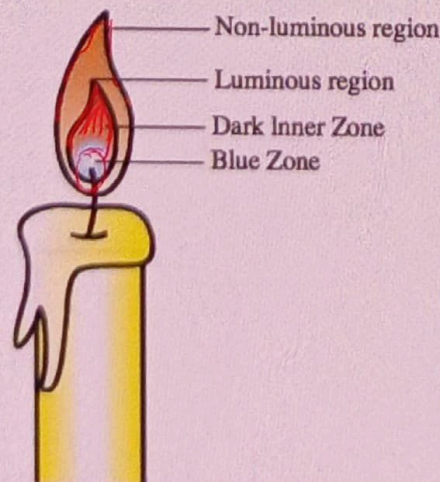
Constitution of normal flame of lamp.

a
→ Inner Zone ⇒ non Combustion

↓ ↓ ↘
non-luminous Coldest zone unburnt Vapour

→ Intermediate Zone ⇒ Incomplete Combustion

↓ ↘
burnt Vapours and white hot carbon
यह Zone maximum light provide करता है।



Flame of a candle

⇒ Outer Zone ⇒ Complete Combustion

↓ ↘
burning ⇒ CO, H₂, carbon particles
Complete Combustion होने पर CO₂ & water
Vapour form

MINING GYAN

Accumulation Test

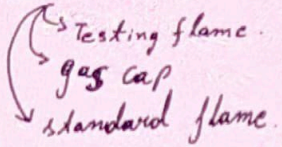
- Gas का accumulation पता करने के लिए यह test किया जाता है
- Mining Sirdar को gas का accumulation मिलने पर Overman को report करेगा
- Accumulation test करने के लिए
 - ① Cap lamp को switch off कर दें।
 - ② FSL के flame को normal size में रखकर आराम से ऊपर ले जायें
 - ③ अगर flame लंबी होती है
 - Spikes (मीनार)
 - Jumps
- ④ तो gas का percentage 3% या उससे अधिक मान सकते हैं।
- ⑤ इससे अधिक ऊपर FSL को नहीं ले जायें
 - ↓
 - lamp के अंदर की air explode हो कर lamp को बुझा देगी।
- ⑥ अगर mixture explosive नहीं होती है तो lamp के अंदर methane के जलने के कारण CO₂ produce होगा और flame को बुझा देगा।
- ⑦ 3% से अधिक methane का clear indication मिलने पर % test करना जरूरी नहीं है।
- ⑧ अगर by chance gauge के अंदर methane जलती है तो :-
 - ① इसे जलने नहीं रहने देना
 - ② lamp को floor के पास ले जाना है
 - ③ वहाँ से सावधानी के साथ fresh air में ले जाना है।
 - ④ अगर यह possible नहीं है तो lamp के inlet को रुमाल से बंद देना

Percentage Test

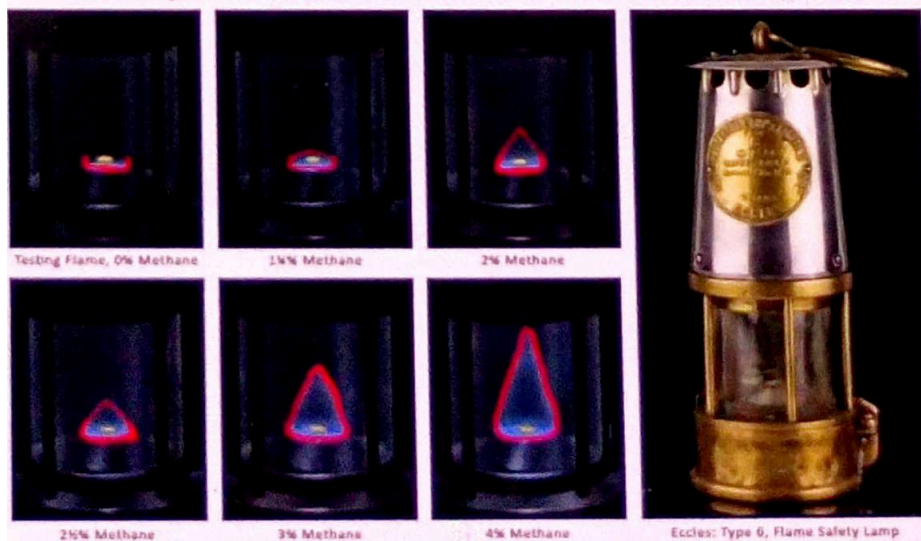
- यह करने के पहले brought light / cap lamp को switch off कर दें।
- नीचे दिया काम कर दें कि उसके ऊपर

(4) अगर यह flame inlet की कमाल से बंद देना

Percentage Test

- यह करने के पहले bought light / candle lamp की switch off कर दें।
- flame की इतना कम कर दें कि उसके ऊपर एक curved blue line न बन जाय
- 
- यह काम जहाँ % test करना है वहाँ नहीं करेंगे → उसके पास gas रहित जगह पर करना है।
- अगर firedamp है तो non-luminous, bluish flame की height change होगी
- ↓
- इसका size & height wick के size & fuel के quantity पर भी depend करेगा

Percentage of Methane in Mine Air as shown on a Flame Safety Lamp



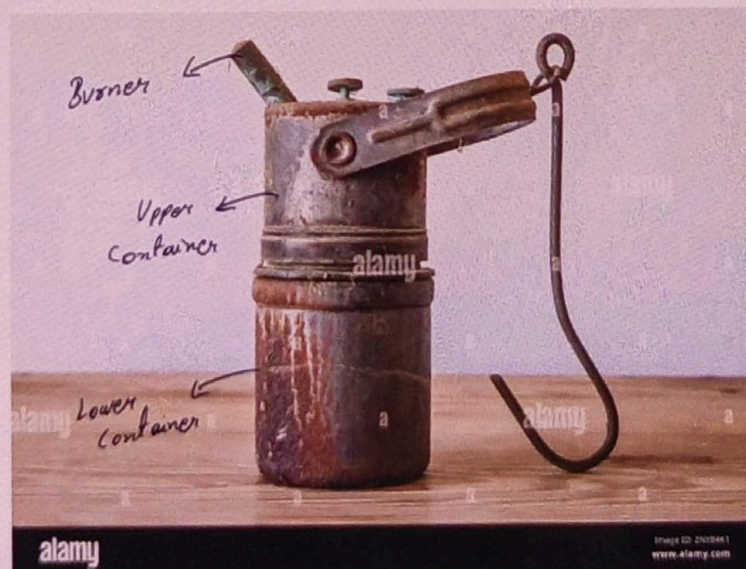
Limitations of FSL

- Trained persons के द्वारा ही use किया जाना चाहिए
- कितना भी experience हो 2% से कम firedamp detect नहीं कर सकते

- कितना भी experience हो 2% से कम firedamp detect नहीं कर सकते
- व्यक्ति की जहाँ तक पहुँच है वही तक detect कर सकते हैं।
- 17% से कम O_2 होने पर FSL बुझ सकता है।
- 14% तक human life को O_2 support करता है।
- 3% या अधिक CO_2 होने पर FSL बुझ सकता है।

Acetylene Portable hand lamp.

- Metal mines आदि में Use करते हैं।
- lower container में calcium carbide होता है जिसमें burner लगा होता है।
- Upper container में water होता है जो की drop by drop lower container में जाता है।
 - ↳ hand operated valve से इसे regulate कर सकते हैं।
- water & calcium carbide के reaction से acetylene gas produce होती है।
 - ↳ burner पर ignite होने से white flame के द्वारा जलता है।



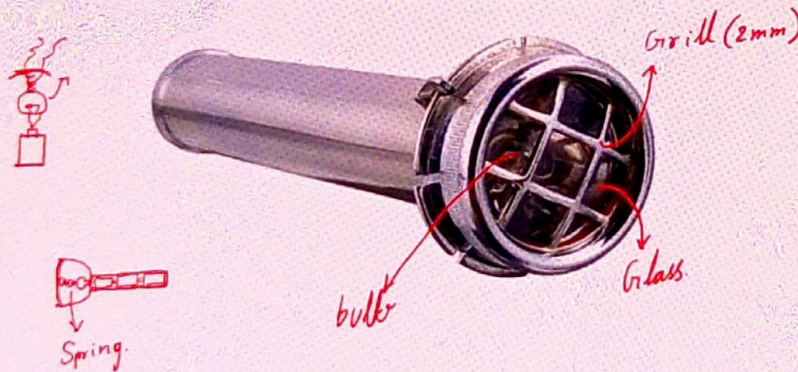
- Oil lamps के मुकाबले यह lamp कम O_2 में भी जलता है।
- oil lamps की तरह यह black damp जल्दी से detect नहीं करता।
- 5 m/s की air velocity को carbide lamp झेल सकता है।
- but safe working के लिए 2.5 m/s से अधिक air की velocity नहीं होनी चाहिए।

MINING GYAN

Flameproof Safety Torch

- Intrinsically Safe apparatus है।
- Torch lamp cabin है locked होता है।
- Mouthpiece का glass toughened acrylic disc से बना होता है (Unbreakable glass)
- Glass को protect करने के लिए 2mm wide grill लगा होता है।
- Bulb को protect करने के लिए spring लगा होता है।
- Glass break होने पर spring बाहर आ जाता है जिसके कारण bulb का battery से contact खत्म हो जाता है।
- Senior supervisory staff के द्वारा use किया जाता है।

Flameproof Safety Torch



Electric Cap Lamp

- Also known as Oldham cap lamp
 - ↳ Manufactured by Mine Safety appliances Co. Ltd.
- battery → 4V की lead acid की rechargeable type होता है।
- Lead acid battery में 2 cells होते हैं।
 - ↳ Lead antimony tubes / plates carry active materials.
 - ↳ Solⁿ of Sulphuric acid (H_2SO_4) & distilled water.
- Fully charged Condition
 - ↳ active material
 - ↳ +ve plates → brown lead peroxide (PbO_2)
 - ↳ -ve plates → Grey spongy lead (Pb)
- Discharge Condition → both plates change into lead sulphate ($PbSO_4$)

Lead antimony tubes / plates
carry active material.

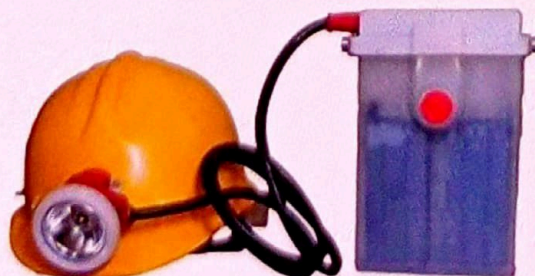
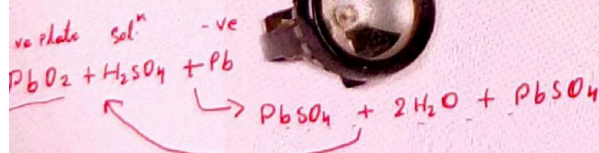
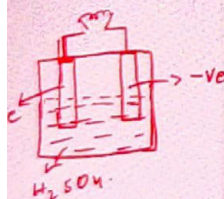
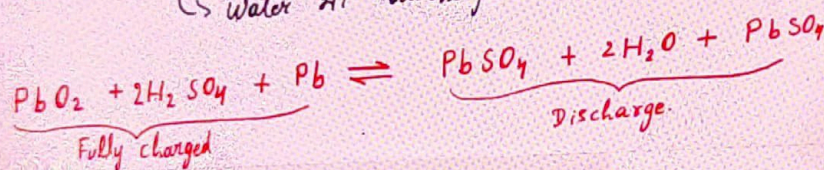
Sol.ⁿ of Sulphuric acid
(H_2SO_4)
& distilled water.

→ Fully charged Condition → active material

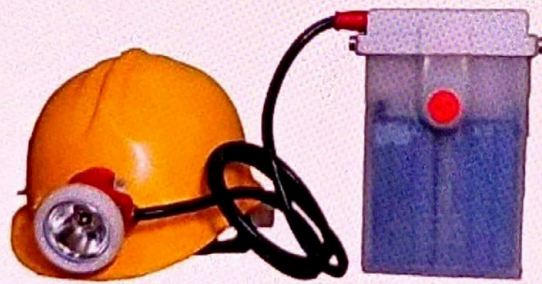
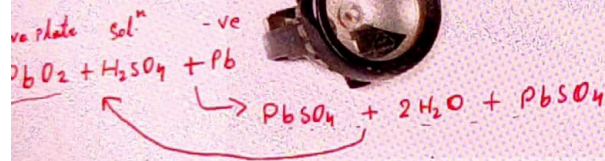
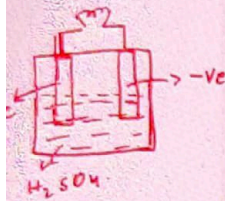
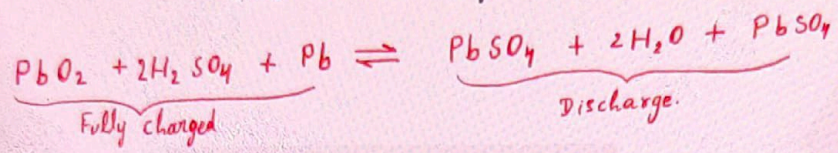
+ve plates
↓
brown lead peroxide
(PbO_2)

-ve plates
↓
Grey spongy lead
(Pb)

→ Discharge Condition → both plates change into lead sulphate
($PbSO_4$)
↳ water at discharge stage



↳ water at discharge state



- Bulb → Krypton gas भरती होती है
- ↳ Voltage → 4V.
 - ↳ Current → 0.67A
 - ↳ Light output → 30 lumens.

→ Bulb → Krypton gas भरी होता है

- Voltage → 4V.
- Current → 0.62A
- Light output → 30 lumens.
- Life of bulb → 500 hours.

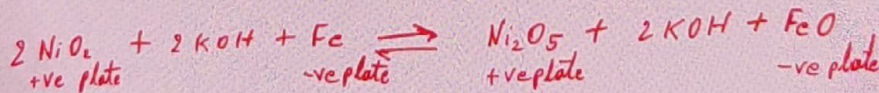
→ Lamp charging room → at least 100 lamps की capacity
 → 102 type changes
 → All lamps are connected in parallel
 → Low Voltage DC power → 5-6 Volts का provide किया जाता है,

Oldham lamp (M.S.A. Cap lamp)

→ इसमें self service system होता है

→ battery → alkaline cell
 → nickel steel plates containing active material.
 20% sol.ⁿ of Potassium hydroxide (Caustic Potash, KOH)

→ Active material → +ve plate → Nickel hydroxide
 → -ve plate → Iron/Cadmium/mixture of two



Advantages of Alkaline Cell over Lead acid battery

- 1) Working life → 5-6 years.
- 2) Low maintenance cost -
- 3) Can withstand adverse treatment → overcharging
 → excessive discharging
 → short circuiting
 → Remaining unused for longer period

→ Lead acid battery → Life 2 years.

- cheap
- high electrical efficiency
- Less cost on replating

Audio - Visual alarm lamp

→ Also called Brattellite audio visual alarm lamp.

→ It consists of → blinking red light.
 → hooter } यह cap lamp में लगा होता है।

→ Used to give warning

Applications

→ It consists of hooter

यह Cap lamp में लगा होता है।

→ Used to give Warning.

Applications

① Shotfiring के द्वारा use किया जाता है।

→ While preparing face for blasting
→ सबसे पास के junction में warning देने के लिए at the time of shotfiring.

② During splitting of pillar.

→ alarm lamp को gallery के पीछे रख देते हैं

③ Danger zones में warning देने के लिए।

Methalarm

→ Cap lamp में fit रहता है

→ To detect methane → 1 to 2.5%.

→ It is intrinsically safe

→ Wheatstone bridge के principle पर work करता है।

Power lighting from Electric Mains

→ Roadways / Strategic location पर illumination provide करने के लिए use करते हैं।

→ Also called General lighting.

→ Illumination → at pit bottom → 20 - 40 lumens/m²

→ at junctions → 15 - 20 lm/m²

→ सभी lights flameproof enclosure में होने चाहिए

MINING GYAN

Miner's Disease and dust hazards.

- ① Nystagmus
- ② Ancylostomiasis
- ③ Pneumoconiosis
- ④ Silicosis
- ⑤ Asbestosis
- ⑥ Siderosis

dust के कारण

Nystagmus

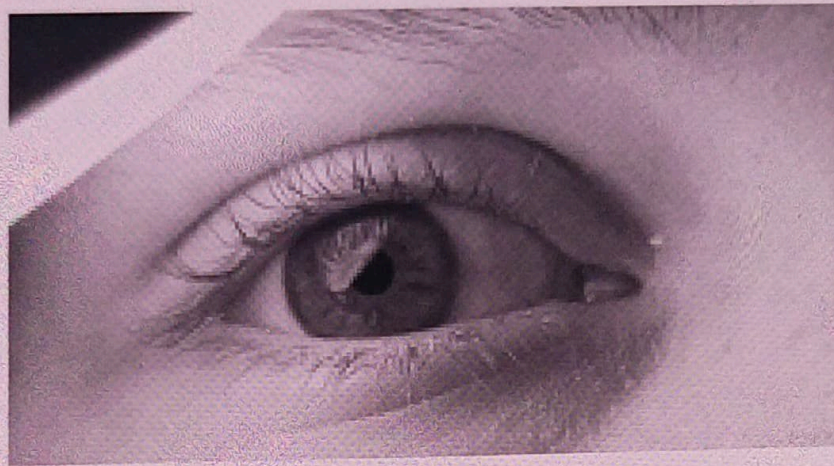
- eyes के muscles & nerves affected होते हैं,
- eyeballs में abnormal movement होने की मिलता है
- cause of disease ⇒ Mine worker जब insufficient light वाली जगह पर लंबे समय तक काम करता है,
- इस बीमारी से affected person FSL का gas cap नहीं देख पाता है
- Periodical eye testing of supervisory staff → once in 5 yrs



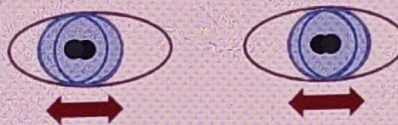
HORIZONTAL NYSTAGMUS



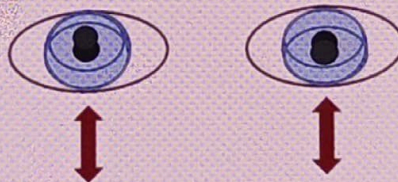
VERTICAL NYSTAGMUS



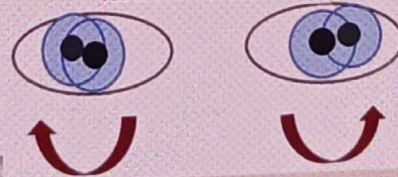
HORIZONTAL NYSTAGMUS



VERTICAL NYSTAGMUS



ROTARY NYSTAGMUS



Ancylostomiasis → हुन सीलासटीमाईसिस

- Also miners Anaemia
- hook worm disease की तरह ही होता
- Caused by → thread like blood sucking worm जो की आपकी skin body में अंदर जाते हैं।
- Caused due to working in →
 - ① Insanitary conditions.
 - ② Coal के cutting
 - ③ जमीन समय तक गाढ़े पानी में नंगी पाँव खड़े रहने के कारण

- Symptoms →
- ① Pain in stomach
 - ② Loss of appetite (भूख)
 - ③ diarrhoea and dysentery

↓
दस्त

↓
पेशाब

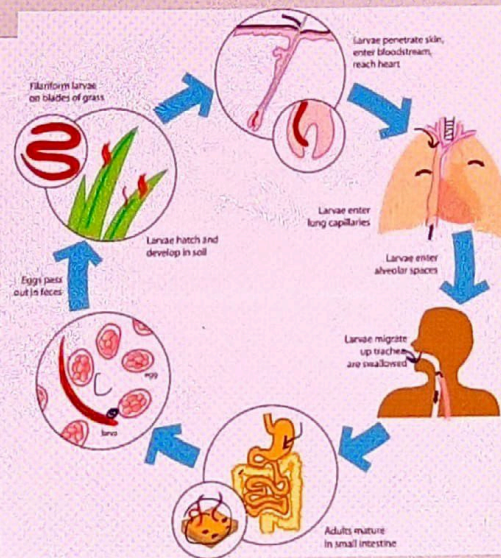
→ seriously anaemic affected व्यक्ति के stools में hookworm के eggs को examine करते हैं।

③ diarrhoea and dysentery

दस्त

टीचिश

→ seriously anaemic affected व्यक्ति के stools में hookworm के eggs को examine करते हैं,



Dust hazards In mines

→ Dust diseases depends on

① Period of exposure

② Nature and concentration of dust.

→ Dustiness of air → air & dust की quantity

① Dust count method → number of dust particles in 1cm^3 of air

② Weight or Gravimetric method → number of mg of dust in 1m^3 of air

Persons affected by dust hazards.

- Operators of
- Coal cutting machine
 - Cutter loader machine
 - Drillers
 - Loaders
 - blasters
 - Conveyor attendants at loading chutes

MINING GYAN

Dust control by respiratory system

- Dust controlling parts in our body → ① hair and mucus in nose
 - ② Mucus in trachea
- Size of dust particles controlled by our body
 - greater than 10μ in dia
- 2μ से कम size के dust particles alveoli की cross कर जाते हैं।
- 40% dust जो inhale किया जाता है nose में ही control कर लिया जाता है & 25 से 30% alveoli में जमा हो जाता है।

→ Alveoli में deposited dust को clean नहीं कर सकते हैं

Pneumoconiosis

- Dust related lung diseases are termed Pneumoconiosis
 - Silicosis → silica & quartz dust
 - Siderosis → Iron oxide dust
 - Berylliosis → Beryllium in form of dust/fumes
 - Asbestosis → Silicate of magnesium
- Limestone, shale & dust harmful नहीं होते हैं।

Classification of Pneumoconiosis

→ It is based on nature of dust and type of tissue response.

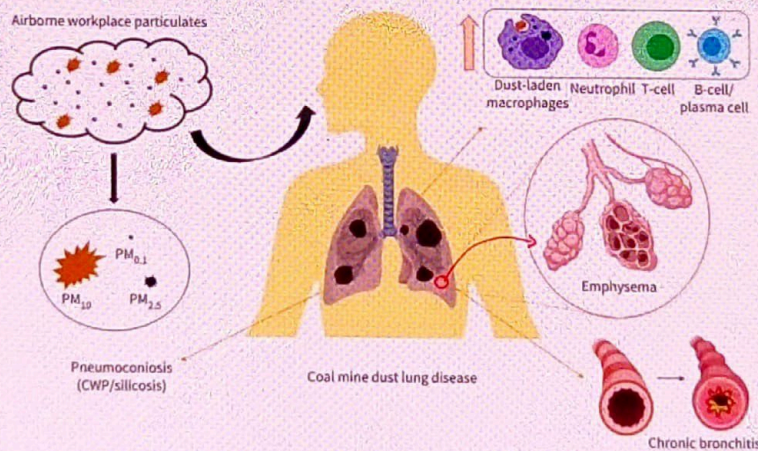
- ① Fibrosis producing → Silicosis & Asbestosis → There are soluble dust
- ② Non-Fibrous producing → Anthracosis → Dust inert होता है
- ③ Toxic and irritant → Lime, dichromate, lead mercury
 - Corrosive nature के होते हैं
 - इसके dust & vapours दोनों ही harmful होते हैं।

Silicosis

- यह lungs के fibrous tissue को affect करता है
- इसके कारण tuberculosis disease होता है।
- ... in ... swelling

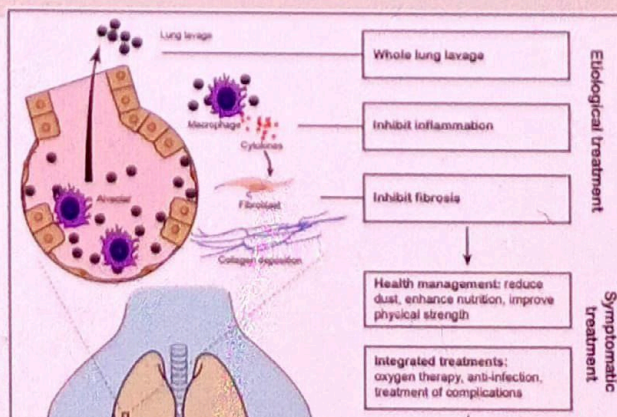
Silicosis

- यह lungs के fibrous tissue को affect करता है
- इसके कारण tuberculosis disease होता है।
- workers engaged in ⇒ stone drifting
 - ② Tunneling
 - ③ Rock drilling
 - ④ stone crushing
- 0.5 μ m to 2.5 μ m in dia वाले silica dust ज्यादा harmful होता है।
- Alveoli में silica dust के particles poisonous silica acid (H_2SiO_3) में convert हो कर blood में mix होता है।



Asbestosis

- caused due to inhalation of hydrated magnesium silicate
- यह silicosis के मुकामलें ज्यादा harmful होता है।
- symptoms दिखने के 5 years के भीतर व्यक्ति की मृत्यु हो जाती

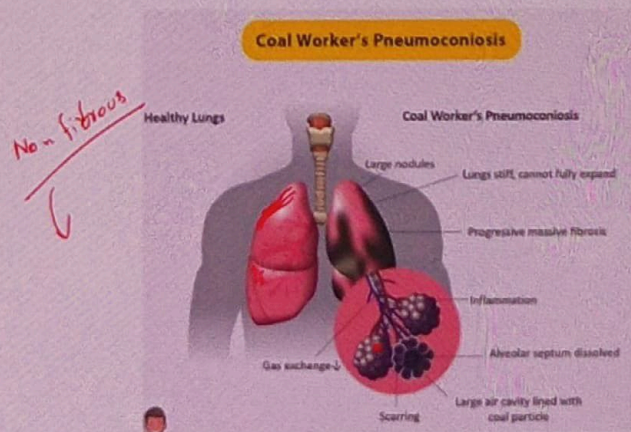


Siderosis

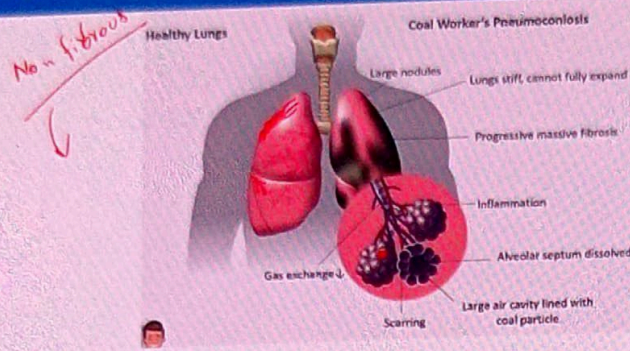
- Siderosis is caused by inhalation of iron dust.
- Electric arc welders को यह disease होता है।
- Electrodes used in welding
 - ↳ 90% ferrous material से बनते होते हैं।
 - ↳ Electrodes से ये fumes जैसे ही निकलते इसके कारण workers affected.

Anthracoosis

- जन अकिते इसी जगह पर होता जहाँ के atmosphere में large amount में smoke है
- यह disease lungs को black कर देता है and इसलिए इसे black lung disease भी कहते हैं।
- इस disease में liver, spleen, bone marrow, lymph affected होते हैं।
- इस disease affected person को tuberculosis हो जाता है।

Permissible levels of dust

- Dust containing more than 70% free silica → 1 mg/m^3
- 10 to 70% free silica → 2 mg/m^3
- Coal / Coal measure dust containing more than **5%** silica → 2 mg/m^3
- Coal dust → less than **5%** free silica → 4 mg/m^3



Permissible levels of dust

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- coal dust → less than **5%** free silica → 4 mg/m^3
- No free silica → 10 mg/m^3

Symptoms of lung disease

Stage 1 → हल्का सा हाफना (shortness of breath)
 → dry cough (सूखी खासी)

Stage 2 → हाफना
 → chest में दर्द
 → morning में सूखी खासी आना
 → काम करने की क्षमता में कमी

Stage 3 → तेजी से हाफना
 → लगातार सूखी खासी आना
 → लगातार थूकना
 → pulse rate बढ़ जाती है,
 → काम करने की क्षमता खत्म हो जाती है,

→ Lung disease को detect करने के लिए
 radiographs का use करते हैं।

MINING GYAN

Remedy in preventing lung disease

- Reducing dust formation at places where workers are engaged
- Collecting the dust by suitable dust traps
- Examining the dust concentration at working places at regular intervals by suitable instruments and taking correcting steps

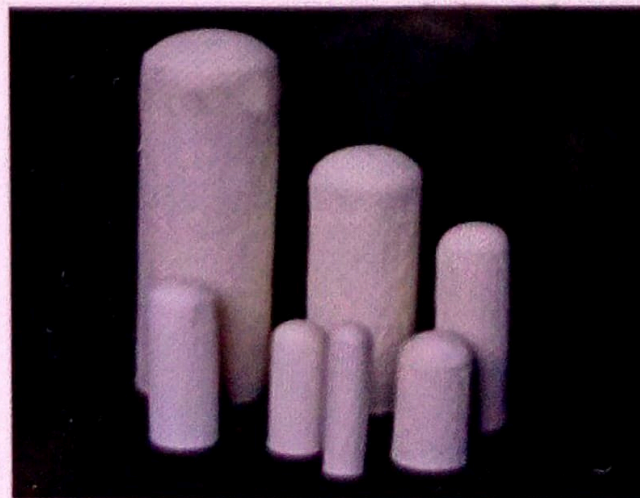
Dust sampling methods

- It is necessary to have a suitable device to estimate or sample airborne dust likely to be breathed by the UG workers
- The sample of dust collected should be able to give knowledge of the dust concentration in the dangerous size range
- The process of estimating by suitable instruments/devices the dust concentration in the collected samples is known as sampling dust

- Filtration
- Sedimentation
- Thermal precipitation
- Impingement
- Electrical precipitation
- Optical method
- Impaction
- Centrifuging

- Mass concentration of dust can be obtained by differential weighing of a suitable filter before and after the collection of sample
- Dust collected by filtration can also be spread on glass slides examined under the microscope for determining the particle concentration and size
- Paper filters are usually made in the form of rigid thimbles
- Air is drawn into the filter papers by a hand pump or by a compressed air injector

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 - The thermal precipitation – It utilises the principle that when a body surrounded by dusty air heated, a dust free zone is produced around the hot body
 - The extent of the dust free zone depends on the temperature gradient between the hot body and the surrounding air
 - Dust in air gets deposited on the glass cover slips at the points A and B
 - After sample collection it is mounted on 75mm×25mm microscope slide and waxed to it so the dust is enclosed between 2 glass surfaces
 - Counting is done with the help of a suitably calibrated graticuled (mesh) eyepiece under a high power microscope

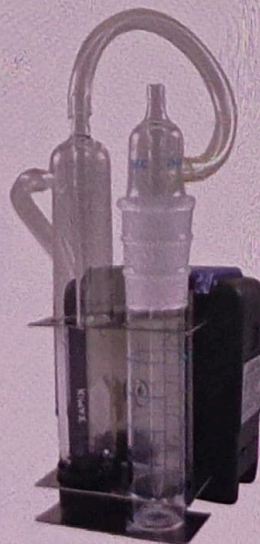
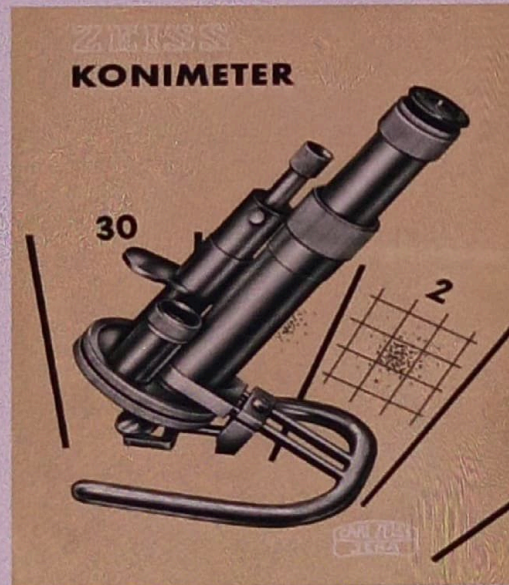


Impingement

- It utilises the principle of inertia precipitation of dust when a fast moving stream of air impinges on a surface

Impingement

- It utilises the principle of inertia precipitation of dust when a fast moving stream of air impinges on a surface
- The most commonly used instruments based on impingement are the konimeter and midget impinger
- Konimeter is a very handy, compact and sturdy instrument suitable for routine dust sampling but it is a snap sampling instrument collecting only 5cm^3 of sample over a period of second thus providing a sampling velocity of the order of 100m/s



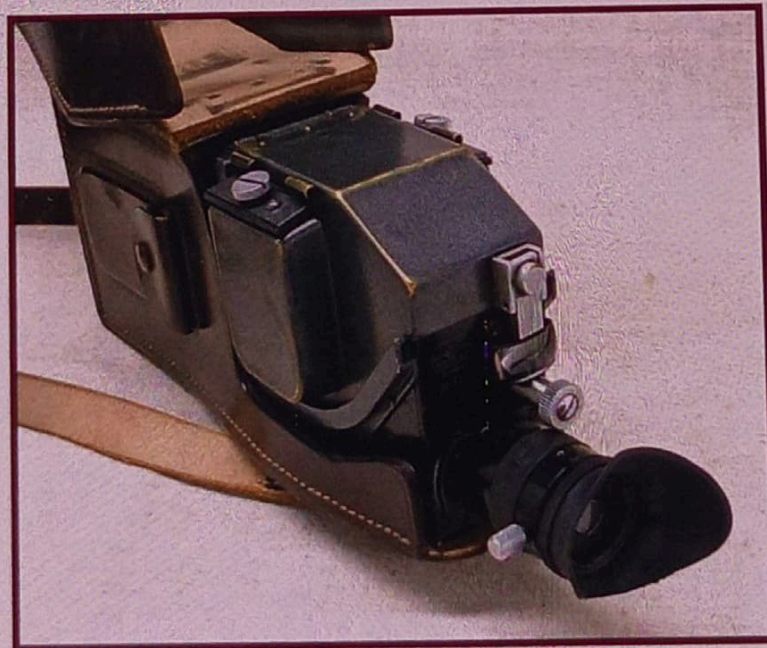
Electrical precipitator

- It essentially consists of a charging wire maintained at a high negative potential of about 12000volts and surrounded by an earthed concentric cylinder
- Dust laden air is drawn through the cylinder by a fan at a constant rate
- The dust particles when passing through the instrument get charged and are drawn to and precipitated on the inner surface of the earthed cylinder
- This instrument has a large sampling capacity and is suitable for collecting large quantities of dust for chemical analysis

- This instrument has a large sampling capacity and is suitable for collecting large quantities of dust for chemical analysis
- The instrument has high collecting efficiency, but the high voltage used in it makes it unsuitable for use in coal mines where filters are preferred

Optical method

- It utilises the property of scattering of light by suspension of fine particles
- The intensity of scattered light is proportional to the surface area of the particles a fact well borne out in practice
- The instrument based on this principle is the **Tyndalloscope**, very commonly used in German coal mines for routine dust sampling purposed mainly because of its cheapness as well as quickness and ease of operation



PRU Hand Pump

- In this a certain volume of dusty air is pumped through a suitable filter paper by means of a hand pump
- The density of the stain on the filter paper is measured photoelectrically in **densitometer** where a beam of light is allowed to fall on a photocell connected to a galvanometer, after passing through the stained filter paper

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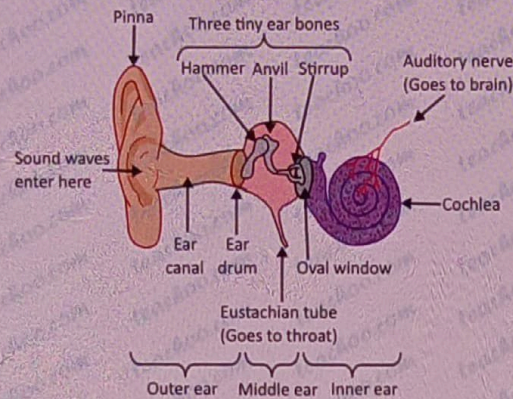
Dust measuring instruments

- Konimeter
- Densitometer
- Midget impinger
- Soxhlet midget impinger
- Sedimentation cell
- PRU hand pump
- Tyndalloscope

Ailments of ear

teachoo.com

Human Ear Structure



Properties of Sound Waves



Sound

- It is generated by rhythmic vibrations of object
- When vibrations are produced in the objects, all these vibrations are imparted to the molecules in the air and get transferred from one molecule to the other. In this way, the vibrations reach our ears and the sound is heard.
- **Pitch of a sound** - In Indian music, the musical notes, Sa, Re, Ga, Ma Pa Dha Ni are of increasingly higher pitch; i.e. of increasingly higher frequency. In scientific terms frequency is a measure of pitch.
- **Periodic motion** - The object moves to one side of the central position and comes back to the central position while vibrating. This motion of an object is repeated again and again at fixed intervals of time. Such motion of an object is called periodic motion.
- Vibrations, that produce sound, can be studied with the help of a simple 'oscillator'.
- **Motion of a swing** - A swing is an oscillator. The motion of a swing is an oscillatory motion.
- **Simple oscillator or simple pendulum** - The object moving from one end to the other end of its central position, again and again in fixed intervals of time is called a simple oscillator or simple pendulum.

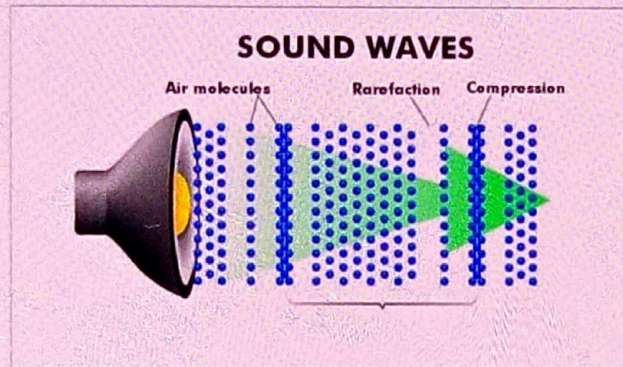
SOUND WAVES

Air molecules

Rarefaction

Compression

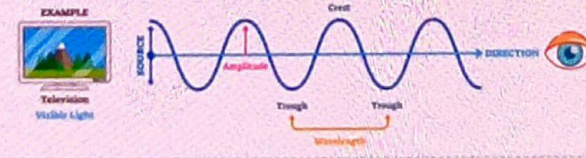
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LONGITUDINAL WAVES



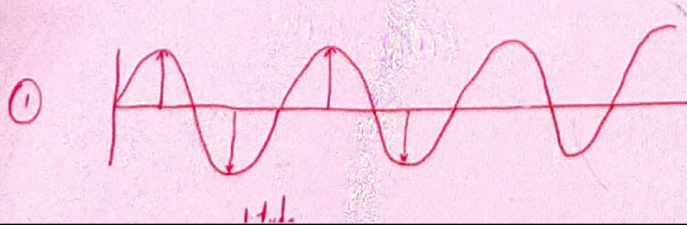
TRANSVERSE WAVES

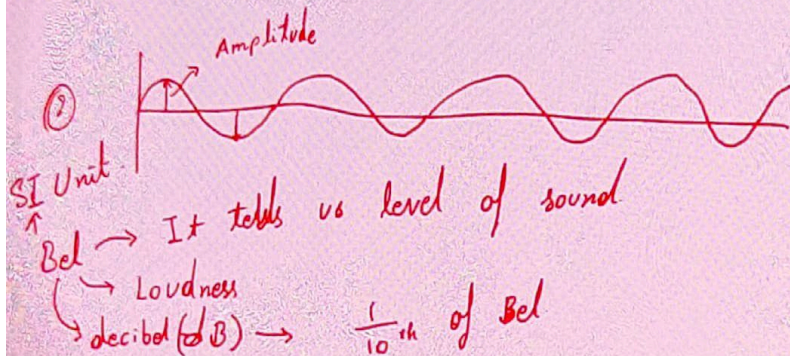
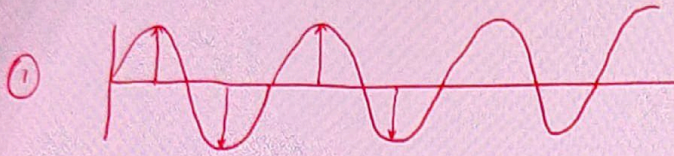


① Frequency is low.

② → frequency is High

frequency → No. of oscillations in 1 sec.
 ↳ It tells about pitch of sound
 SI Unit ⇒ Hertz (Hz)





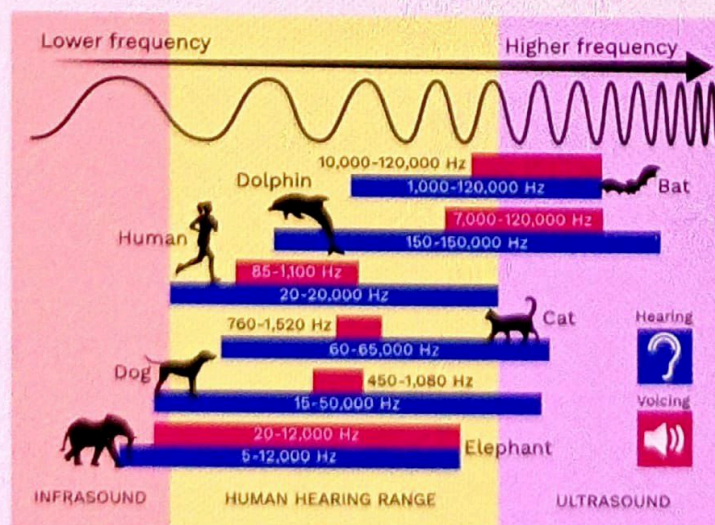
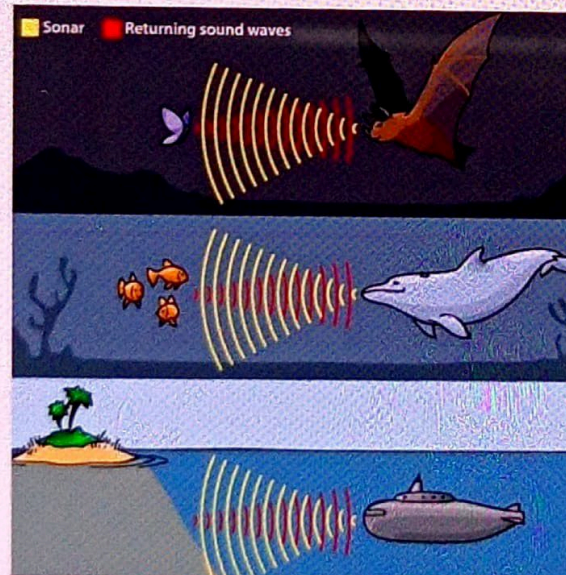
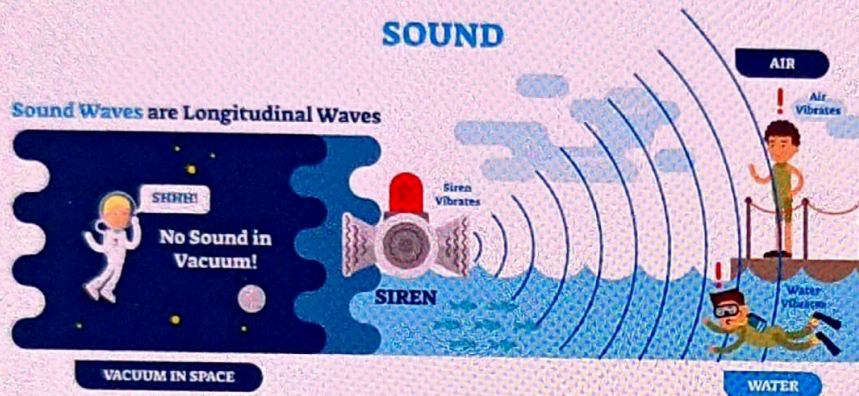
- **Oscillatory Motion of Oscillator** - The back and forth motion of an oscillator on either side of central position is called oscillatory motion.
- **Oscillation of Oscillator** - When an oscillator moves from one end to the other and returns to its starting point, it is said to have completed one oscillation.
- **Amplitude** - The maximum distance covered by an object on any one side of its central position while undergoing vibrations, is called amplitude of vibration.
- **Pendulum** - An oscillator which is made up of a small iron or wooden ball tied to a half a meter long strong thread and the other end of the thread is tied to a fixed support such that the ball is freely suspended in the air. Such an oscillator is called a pendulum.
- **Elasticity** - A stretched rubber comes back to its original state on releasing. This property is called elasticity.
 - When a stretched rubber band vibrates, elasticity works on the stretched rubber band.
 - While the pendulum oscillates, earth's gravitation works on it.
- **Time Period of Oscillation** - The time taken by an oscillator to complete one oscillation is called the time period of the oscillator.
 - Time period is denoted by letter 'T'
 - Time period is measured in seconds
- **Frequency of Oscillation** - The number of oscillations completed by an oscillator in one second is called the frequency of oscillation.
 - Example: Consider, an oscillator completes 30 oscillations in one second, then the frequency of that oscillator is 30 Hertz.
- **Unit of frequency** - Hertz is a unit of frequency.
 - Example: Frequency of 1 Hz means one oscillation in one second. Frequency of 100 Hz means there are hundred oscillations in one second.
 - Frequency is denoted by letter ' η '
 - $$\frac{1}{\text{Time period of oscillation (T)}} = \frac{1}{T}$$

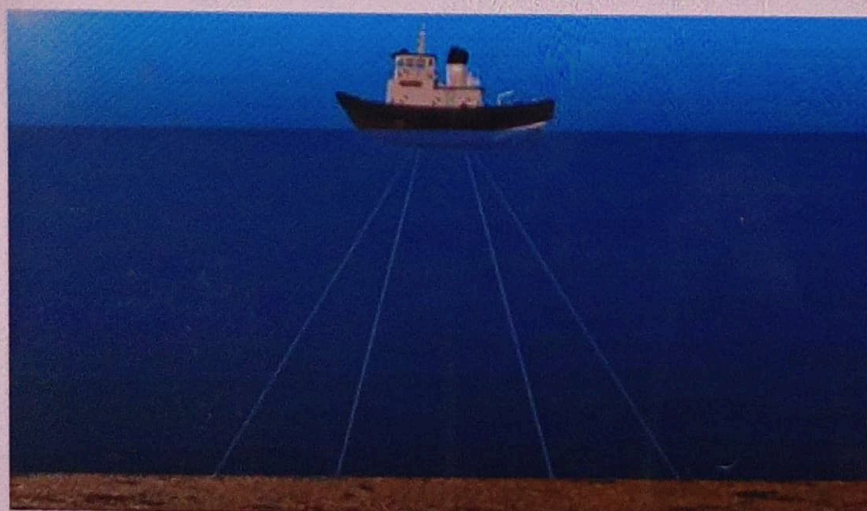
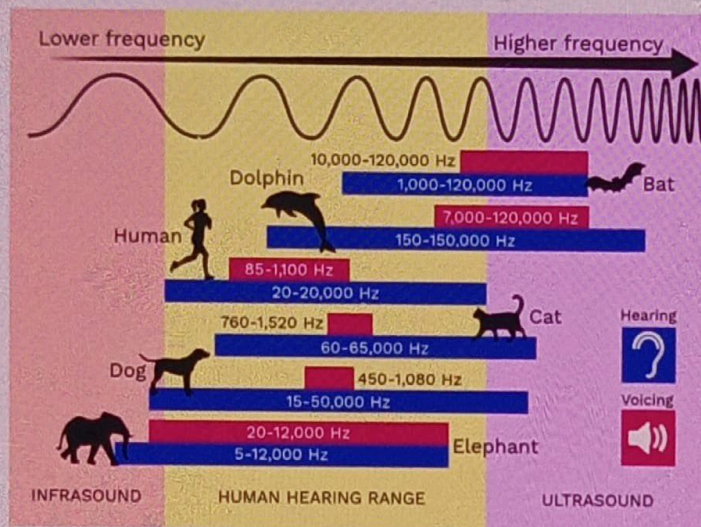
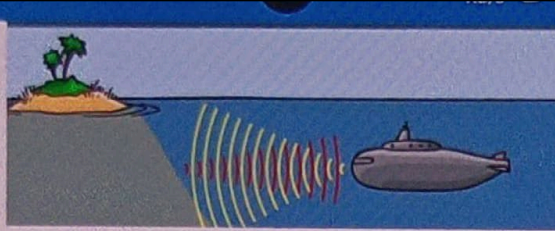
Sound levels

- Hearing gets temporarily affected by sounds of frequency greater than 1000 Hz and levels of sound higher than 100 dB. This can result in temporary deafness. This is experienced by the workers who work near aeroplane engines.
- **Audible sound** - The human beings can hear the sounds having frequency between 20 Hz to 20000 Hz. Therefore, the sounds with frequency 20 Hz to 20000 Hz are called audible sounds.
- **Infrasonic sound** - A sound having frequency less than 20 Hz is not

- **Infrasonic sound** - A sound having frequency less than 20 Hz is not audible to the human being. Therefore, the sound having frequency less than 20 Hz is called infrasonic sound.

- Sounds having a frequency less than 20 Hz are produced and can be heard by whales, elephants, hippopotamuses and rhinoceros.





- **Ultrasonic sound** - A sound having a frequency higher than 20000 Hz is called ultrasonic sound.
 - Ultrasonic sounds cannot be heard by human beings.
 - Some animals like dog, cat, dolphin, sea lion and bat can hear such sounds.



- **Ultrasonic sound** - A sound having a frequency higher than 20000 Hz is called ultrasonic sound.
 - Ultrasonic sounds cannot be heard by human beings.
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- **Uses of ultrasonic sound**
 - To clean tiny parts of a watch and delicate ornaments.
 - To observe internal organs of the body.
 - To detect tumours in the brain.
 - To detect faults in a metal.
 - Ultrasonic sound is used in RADAR systems. To kill certain microbes and insects.
 - SONAR (Sound Navigation And Ranging) is used to locate (determine) the depth of seabed or the position of a ship.

Decibel

- The second unit of sound is bel
- It is a technical term named after the inventor of telephone Alexander Graham Bell
- Most commonly used unit is decibel (dB), which is $1/10^{\text{th}}$ of a bel
- A whisper at 1m distance is 30dB
- While the noise level of an ordinary conversation at 1m distance is 60dB
- Frequency measures the pitch of noise
- Decibel measures the intensity of noise

Effects of noise

- Prolonged exposure to noises greater than 70 to 85dB may damage ear temporarily or permanently
- Under persistent noise the vessels carrying blood to the brain dilate and thereby transport more blood there causing headache
- Red blood cells compact within the thin blood vessels and the vessels may contract in spasms. This may cause the blood to thicken leading to heart attack
- The lesser evils are:-
 - Hearing loss
 - Psychological emotional distress
 - Increased heart beats
 - Indigestion
 - Tension
 - Increase in blood pressure
 - Sleeplessness

MINING GYAN

Inundation

Causes

- (a) due to waterlogged workings
- (b) Goaf & sump filled with water
- (c) lower seam at higher place than present working
- (d) upper seam having connection with the working by fault
- (e) Water bearing strata

Precautions

- (1) Update water danger plan → (a) from time to time
(b) before rainy season
- (2) Scheme of working shall be prepared
- (3) Determine → Position, depth & extent of following places & workings
 - (a) Any place underlying another
 - (b) lower level place.
 - (c) Any place approaching fault
- (3) If working is within 60m of any working containing water or water body.
↓
Take permission from CIM.
- (4) Whenever abnormal seepage is noticed
 - (a) Stopped work Immediately
 - (b) Inform CIM & RIM Immediately
 - (c) Working shall be resumed after taking permission from CIM & RIM.
- (3) Prevention → Make proper Provisions
 - (a) To prevent eruption of water.
 - (b) To prevent accidents

- (a) Stopped work Immediately
- (b) Inform CIM & RIM Immediately
- (c) Working shall be resumed after taking permission from CIM & RIM.

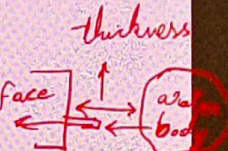
3) Prevention. → Make proper Provisions

(a) To prevent eruption of water.

(b) To prevent accidents

(c) Take permission from CIM

for extending working within 60m of waterlogged place



(d) This 60m distance is the shortest distance from working in all direction

(c) for taking permission from CIM.

↳ Submit 2 copies of plan & section along with application.

(i) Outlines of disused or abandoned working.

(ii) Depth of disused or abandoned working.

(iii) Outlines, layout & method of working.

(iv) faults, dykes & geological disturbance

(f) Height or width of such workings.

↳ Not more than 2.4m.

(g) Advance borehole → At intervals 5m. but not more than that.

→ Length → not less than 3m.

→ Supervision → Managers or overmans

- He will maintain record
- (a) exact height & width of working
 - (b) Number of holes driven
 - (c) length, place & direction of borehole.
- Sign & countersign by Hgr. eng
- Certificate

(h) Plans & section shall be kept up to date

↳ at least once in every 15 days

Development within 60m of waterlogged working

16:16 254 KB/s 5G+ 73

Development within 60m of water logged working

① When working is within 120m $\rightarrow$ Re-survey must be done.

$\rightarrow$ ① Quantity & Pressure of water

② Depth of water logged workings.

③ Nature of strata.

④ Presence of fault, borehole, shaft, drift etc.

② Dewatering

③ Permission $\rightarrow$ If dewatering not possible

④ Scheme of working $\rightarrow$ Prepared by manager

⑤ Working $\rightarrow$ ① Height & Width $\rightarrow$ not less than 2.7m

② Advance borehole $\rightarrow$ at intervals not more than 5m

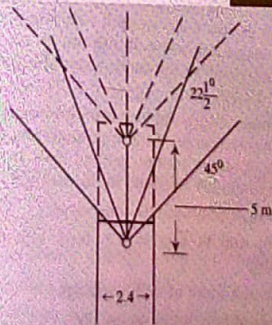
⑥ Ab normal seepage $\rightarrow$ Immediately Inform RIM & CIM and stop work. length not less than 3m

⑦ All work shall be done under supervision of overman or assistant manager.

Pattern of hole

$\rightarrow$ Interval not more than 5m

$\rightarrow$ Length not less than 3m



Other Precautions

① Effective support.

② Good ventilation at face.

③ Check $\rightarrow$ CH_4 , CO & H_2S .

④ Use of safety lamps.

⑤ Pumping arrangement.

⑥ Inspection of escape routes.

Important Things

$\rightarrow$ When working is within 120m of water logged area then surveyor shall record full facts related to

$\rightarrow$ Warning line $\rightarrow$ within 120m of water body.

$\rightarrow$ Green verged yellow

$\rightarrow$ Statutory Restriction line $\rightarrow$ within 60 of water body $\rightarrow$ Green Verged green.

$\rightarrow$ Check Survey $\rightarrow$ It is done for barriers against water logged working

$\rightarrow$ when working is within 120m.

- Green verged green
 → Check survey → It is done for barriers against water logged working
 → When working is within 120m.

Check survey is to be carried out also.

- ① Before abandonment or discontinuance
- ② On re-opening after abandonment or discontinuance
- ③ Before starting depillaring.
- ④ Every 500m advance of U/g working.
- ⑤ On change of ownership of mine.

offset plan → RF → 500:1

- Surface features within 25m of railway, roads & public works.
- Surface features within 15m of river/canal/lake/surface reservoirs.

Water Danger Plan.

- Water bodies either belowground or surface within 200m of mine boundary.
- Position → belowground workings, borehole, shaft drive, cross cut, staple pit, (along with depth)
- Position → dyke, fault & geological disturbances (amount & direction of throw & hade)
- Every source of U/g water within 60m of working
- Every dam or anything constructed to withstand water pressure

Causes of Inundation

- ① Mine entrance, borehole, fault or subsidence (if they are not adequately above HFL of

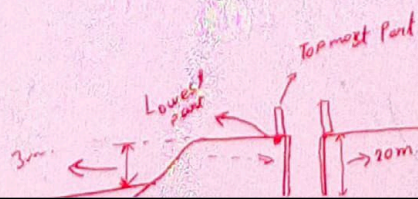
- Position → dyke, fault & geological disturbance
(amount & direction of throw & hade)
- Every source of vlg water within 60m of work
- Every dam or anything constructed to withstand water pressure

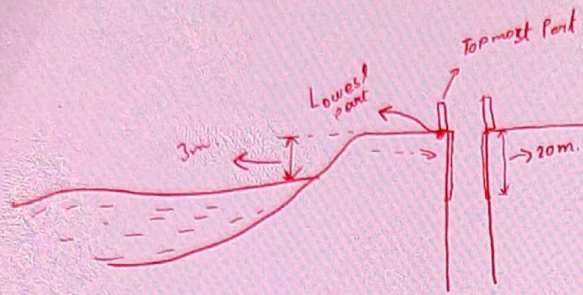
Causes of Inundation

- 1) Mine entrance, borehole, fault or subsidence (if they are not adequately above HFL of nearby river or fore).
- 2) Development of cracks or potholes in water logging subsidence area.
- 3) Formation of pothole due to working at shallow depth or in weak strata.
- 4) water accumulated in o/c mine
- 5) Failure of embankment of pond or overflowing.
- 6) sudden rise in water level of river due to obstruction in flow.
- 7) Conducting depillaring below or near river
- 8) Failure of weak or fire affected pillars below river.
- 9) sudden rise of water level in river due to release of water from dam.
- 10) Inaccurate & Incomplete mine plan.

Prevention from Surface sources.

- 1) No working below or within 15m of boundary of water body.
- 2) stability & seepage shall be regularly monitored by senior official or manager.
- 3) Mine entrance → shaft shall be built with highest for upto 20m depth.
→ Lowest part shall be at least 3m above HFL.
- 4) Monitoring of HFL. above HFL.





⑤ Embankment → if mine entrance is within 1.5 m of HFL then embankment shall be constructed.

Top width
not less than
3m.

→ Height → at least 1.5 m.

→ if there is any major river then Height - at least 3m.

→ fitted with non-return valve.

⑥ Monitoring → by competent person.

→ once in every 14 days, during rainy season.

→ once in every 30 days, during other season.

→ once in every quarter by manager.

⑦ Closed or abandoned shaft → shall be sealed.

→ Surface bore holes sealed by concrete plugs.

⑧ Subsidence area → shall be sloped to flow out water.

→ make embankment & water garland.

⑨ water tank on rise side of pond.

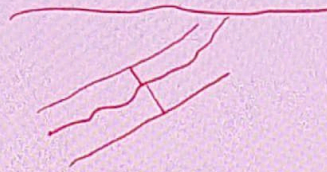
⑩ No working → if hard strata thickness is less than 7.5 m.

→ if hard strata thickness is 7.5 m to 15 m, working permission from DGMS.

⑪ A barrier of 7.5 m to 10 m shall be left on either side of fault.

⑫ Mine barriers in all seams shall be vertically above one another to prevent transfer of danger from adjacent mine.

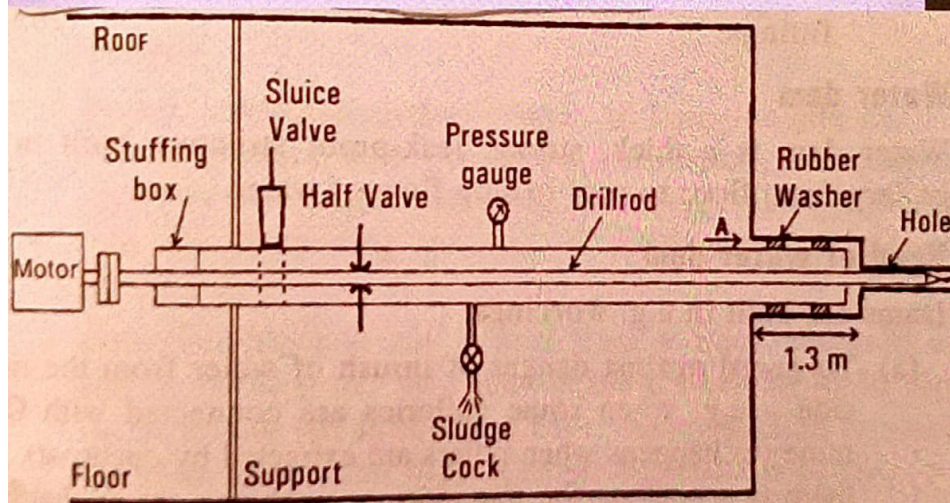
12) Mine Safety
vertically above one another to prevent transfer of danger from adjacent mine



Burnside Safety boring M/c.

→ special features

- ① Flow of water met can be controlled or cut off when rods are in hole.
- ② Drill rods can be withdrawn while bore hole is under pressure.
- ③ Sealing prevents water from running through breaks in the strata.



- Description → Trolley mounted
- 2 units → drive unit & drill
 - Rod dia → 38 mm.
 - Rod length → 1.5m
 - Bit dia → 56 mm
 - ↳ Tungsten Carbide
 - Reamer dia → 110 mm.

Water Dam

Need of water Dam

- ① To guard against danger of inrush of water from the rise side
- ② To guard against irruption of water from adjacent old workings.
- ③ To hold water during rains for pumping out during later months.
- ④ To store water on the rise side

Legal requirements

- ① Notice to be sent to RIM at least 14 days before such construction.
- ② Supervision → Asst. Mgr. / Civil Engineer (Graduate)

Site & Design

- ① Stable
- ② Resist Gwelling
- ③ free of fault, cracks.
- ④ On Inbye side of pillar
- ⑤ Approachable throughout life of mine
- ⑥ It may be flat or sloping
- ⑦ It may be made of brick or concrete.
- ⑧ Thickness depends on
 - ↳ (a) Head of water
 - ↳ (b) Gallery size
 - ↳ (c) Nature of strata

$$\text{Thickness of dam} \Rightarrow T = \frac{H W \sqrt{W}}{8 S}$$

where, T = Thickness of dam in m.

H = Head of water (m)

W = width or height of gallery, whichever is more (m)

S = Crushing strength

→ factor of safety → 10

→ if H is less than 60m → 25% is added in T

It is b/w 60 - 150m → 10% is added in T

→ Thickness → Brick dam → not less than 1.8m.

concrete dam → not less than 1.5m.

Construction

- ① To keep the site dry → Retaining wall of height 0.6 m to 1m is made across the roadway fitted with drain pipe of dia 75 to 200mm.

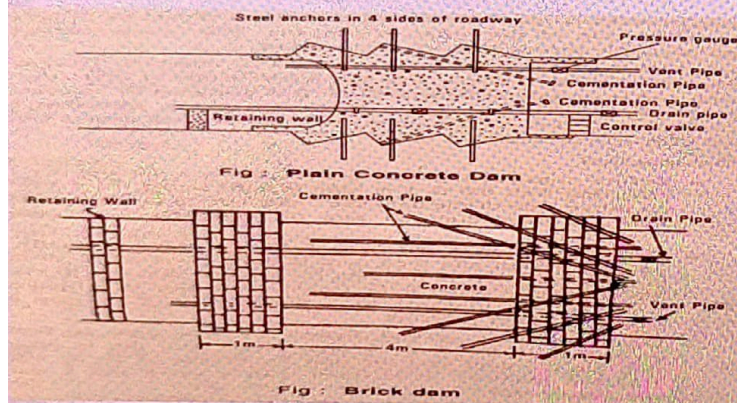
- ② Dam foundation → cut in roof, floor & sides
→ Several pipes of dia 30-50mm fitted for water to flow out

across the roadway,
fitted with drain pipe of
dia 75 to 200mm.

- ② Dam foundation → cut in roof, floor & sides
→ Several pipes of dia 30-
are fitted for cement injection
→ Cement injection done from
bottom to upwards to a pressure
of 2-3 times of water pressure

③ Air vent pipe near the roof. (20-25mm dia)

→ Stop Valve
→ water gauge.



Water Danger Plan

- Position of mine workings
- Position of every borehole, shaft, drift, every geological disturbance, subsidence area, fault.
- Spot level of every → Junction of haulage
→ at end of headings
- Every source of water within 50m of working
- Surface contours → whole area lying within 200m of workings
- Surface drainage system → Intervals → not more than 5m
→ not more than 10m
- HFL
- Reduced level of permanent Bench Mark.
- Every goaf & pumping station.
- Warning lines.
- Cross section of river.
- Incline openings through of working
- statutory restriction line.